Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

TABLE OF CONTENTS, Page 33

TECHNOLOGY DEPARTMENT

JUNE, 1947

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DETROIT

A recent installation of a modern

HIGH SPEED

FOUR-HIGH TANDEM MILL

for the cold reduction of
Stainless and Silicon Steels

DESIGNED AND BUILT
by
MESTA

MESTA MACHINE COMPANY PITTSBURGH, PA.

—But not bothered

The switch mechanism in the new Cutler-Hammer line of safety switches is designed to withstand safely any degree of heat that can be expected from correctly selected fuses.

In addition, C-H safety switches provide greater ease of installation, greater convenience of operation, proved performance, smart styling . . . more reasons why more and more alert contractors and Cutler-Hammer wholesalers from coast to coast feature and recommend this outstanding line of safety switches. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SAFETY SWITCHES
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 24, No. 6.

HYDRAULIC PRESS

By AETNA-STANDARD

DESIGNERS AND BUILDERS
to the Steel, Non-Ferrous
and Chemical Industries

★ HAS MANY NEW DESIGN FEATURES ★

- Open throat.
- High ram lift.
- Adjustable ram pressure from zero to maximum press capacity.
- One-piece construction — no bolted connections.
- All welded, stress relieved construction.

— Available in Four Sizes!

Aetna-Standard, renowned for seamless tube mills and many production machines, *now offers to the trade, a versatile, hydraulic press.* Designed for a specific application, this press can be easily adapted to diversified operations on ferrous and non-ferrous materials . . . light forging, moulding, hot die work, hot and cold forming, straightening and high pressure forming. The press has proved a standout in service.

The designers, specialists in mill equipment, incorporated several outstanding features. The ram pressure moves from zero to maximum press capacity. An automatic dual pump system permits rapid approach and high pressure work stroke.

Aetna-Standard's traditional rugged, rigid, long-wear quality is reflected in this press. The main frame and table is one-piece construction . . . no bolted connections to shake loose. The all-steel cylinders have centrifugally cast manganese bodies.

Speeds range from 4 ft. to 10 ft. per minute with high return speeds. Available in four sizes — 25, 50, 150 and 250 tons.

Complete information promptly upon request.

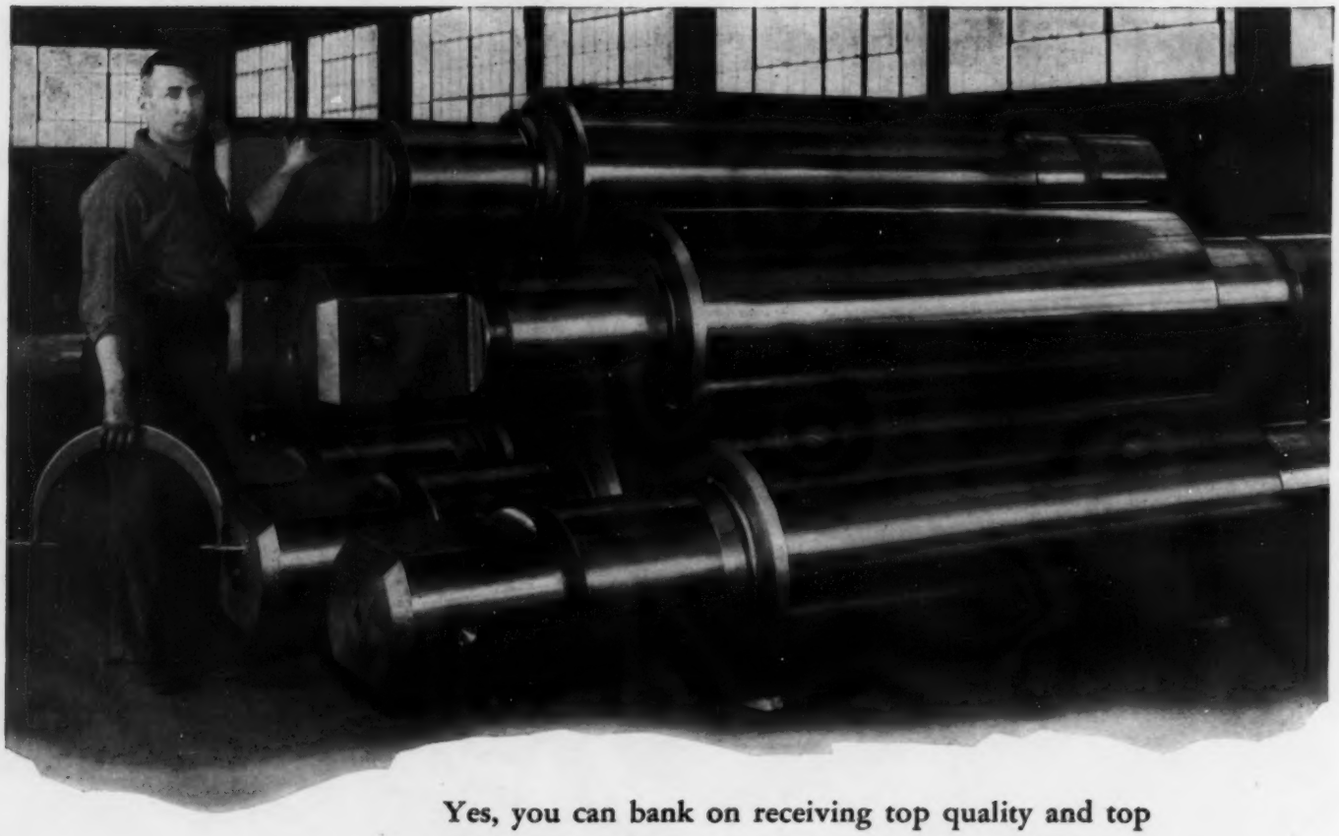
used for:

- MOULDING
- HIGH PRESSURE FORMING
- HOT DIE WORK
- LIGHT FORGING
- HOT AND COLD FORMING
- STRAIGHTENING

THE AETNA-STANDARD ENGINEERING CO.
YOUNGSTOWN, OHIO

ASSOCIATED COMPANY:
HEAD, WRIGHTSON & CO., LTD., THORNABY-ON-TEES, ENGLAND

HERE'S A BANK OF ROLLS YOU CAN "Bank On"



Yes, you can bank on receiving top quality and top performance from every National roll you buy. For in the National foundry only the latest metallurgical practices are employed to assure sound roll castings that measure up to every service specification. And in the modern roll shop, the best of machine tools are used to finish grind roll surfaces — to accurately cut roll passes, splines and wabblers.

For real roll value — specify National. You'll find them second to none in terms of tonnage formed and long service life.

National Rolls

THE NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PENNSYLVANIA

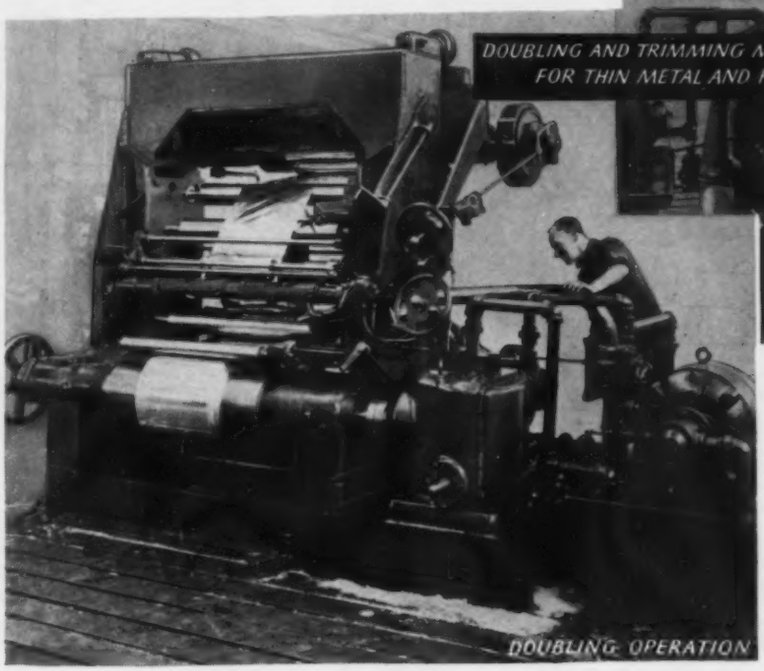
WE BUILD
ROLLING MILLS
AND ROLLING MILL EQUIPMENT

HOT AND COLD ROLLING MILLS
FOR FERROUS AND NON-FERROUS METALS

High Speed Mills for Thin Metal and Foil/ Rolling Mills for Blooms, Bars, Sections, Wire Rod, Plate, Sheet, Strip/Continuous Billet, Strip and Merchant Mills/Structural, Rail and Sleeper Mills, etc.

UNWINDING OPERATION

DOUBLING AND TRIMMING MACHINE FOR THIN METAL AND FOIL



DOUBLING OPERATION

BY COURTESY OF THE ALUMINUM COMPANY OF CANADA LTD., INSTALLATION AT KINGSTON PLANT

ROLLING MILL AUXILIARY EQUIPMENT

Doubling and Trimming Machines/Roller Straightening Machines (Levellers)/Lifting and Tilting Tables/Shearing and Slitting Installations/Flying and Stationary Shears /Guillotine Shears/Circular Shears etc.

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AND SPECIFICATIONS

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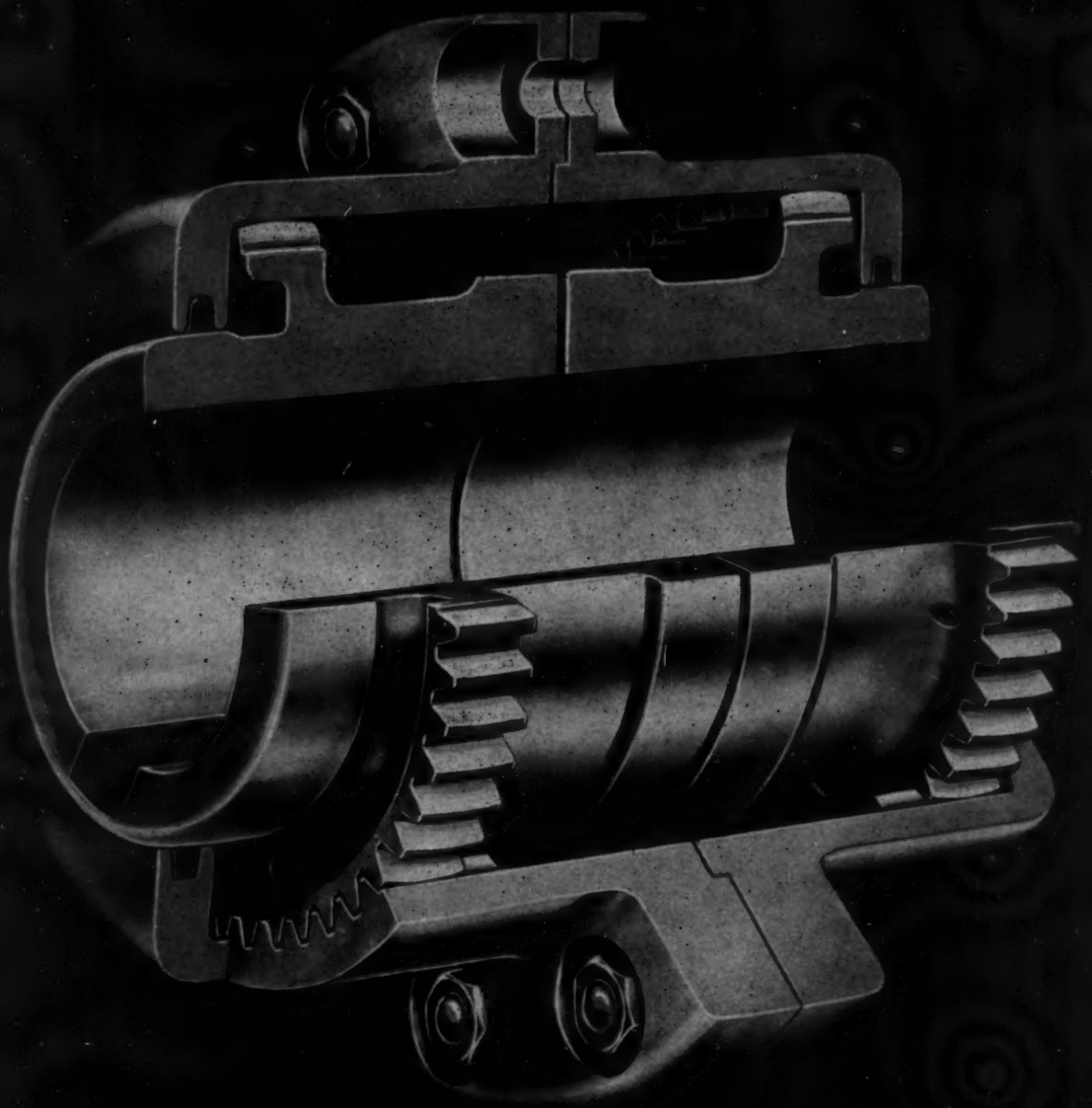
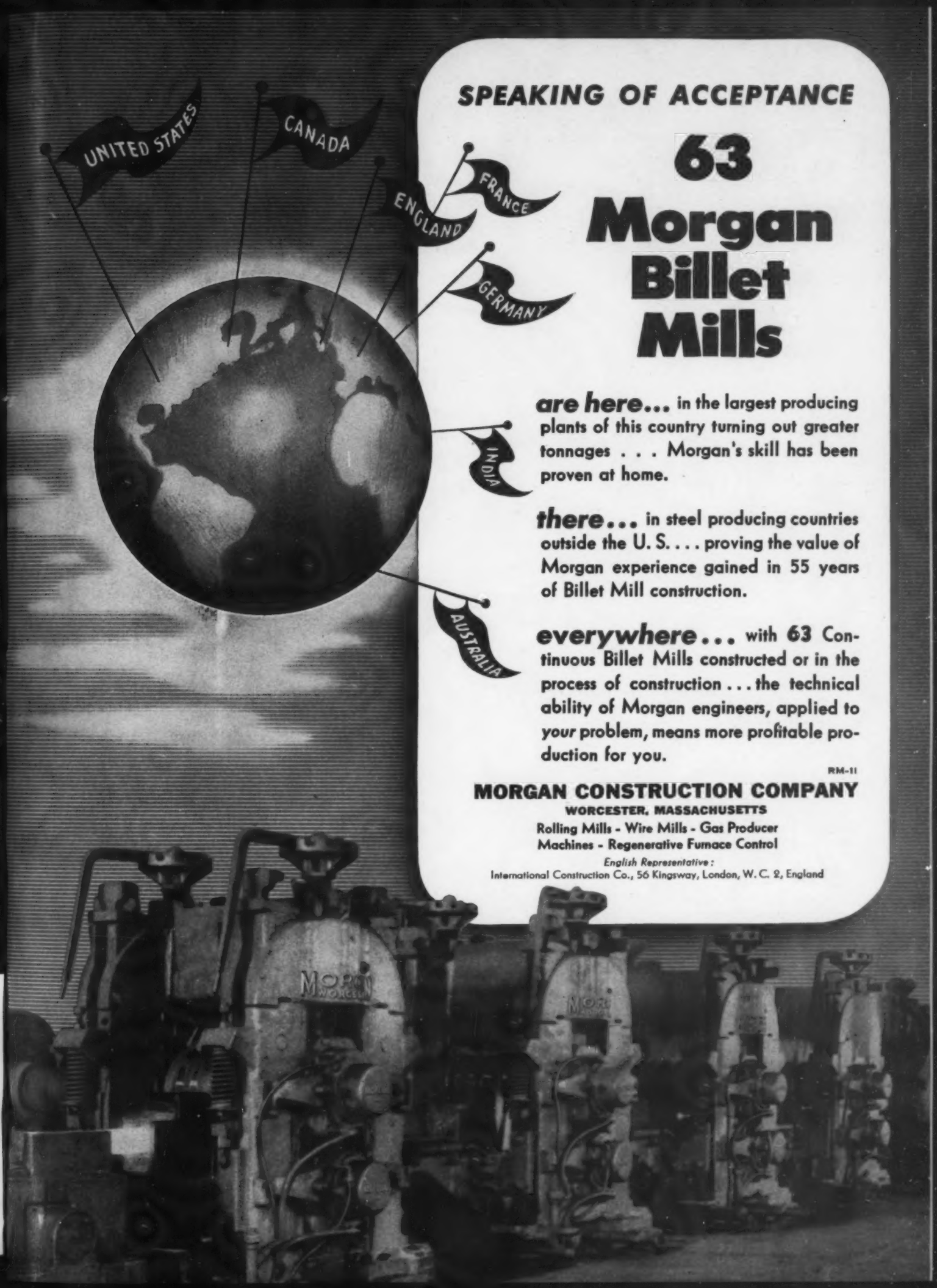
POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.



SPEAKING OF ACCEPTANCE

63 Morgan Billet Mills

are here... in the largest producing plants of this country turning out greater tonnages . . . Morgan's skill has been proven at home.

there... in steel producing countries outside the U. S. . . . proving the value of Morgan experience gained in 55 years of Billet Mill construction.

everywhere... with **63** Continuous Billet Mills constructed or in the process of construction . . . the technical ability of Morgan engineers, applied to *your* problem, means more profitable production for you.

RM-11

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS
Rolling Mills - Wire Mills - Gas Producer
Machines - Regenerative Furnace Control

English Representative:
International Construction Co., 56 Kingsway, London, W. C. 2, England

DOWELL

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

This Economizer was Chemically Cleaned!

FULL EFFICIENCY RESTORED

SAFELY, RAPIDLY, THOROUGHLY!

To keep this economizer living up to its name, it has been *chemically* cleaned many times. Every one of its tubes and 440 return bends has been cleaned in place—without dismantling. The cleaning operation usually takes less than 12 hours—with resultant higher efficiency and the avoidance of frequent cleaning of the boiler.

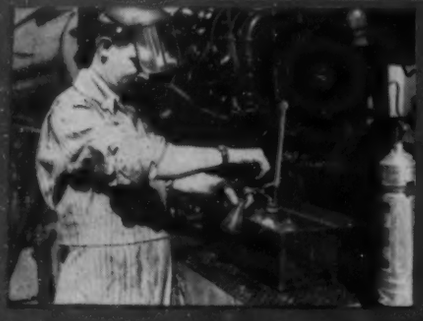
Economizers may be cleaned separately—or along with the boiler. Dowell engineers fill the equipment with selected liquid solvents designed to dissolve and disintegrate power-stealing scale and sludge. They use special truck-mounted tanks, pumps, mixers, heaters and control equipment.

To save dismantling and down time—to reduce operating costs—to maintain efficiency in heat exchange equipment, boilers, condensers, water lines and water wells—call the nearest Dowell office.

DOWELL INCORPORATED · TULSA 3, OKLAHOMA

New York, Boston, Philadelphia, Wilmington, Baltimore, Pittsburgh, Buffalo, Cleveland, Cincinnati, Detroit, Chicago, St. Louis, Kansas City, Wichita, Oklahoma City, Houston, Fort Worth, Shreveport, Mt. Pleasant, Michigan; Salem, Ill.; Borger, Texas; Wichita Falls, Texas; Midland, Texas; Lafayette, La.

Long Beach, Casper: Dowell Associate—International Cementers, Inc.

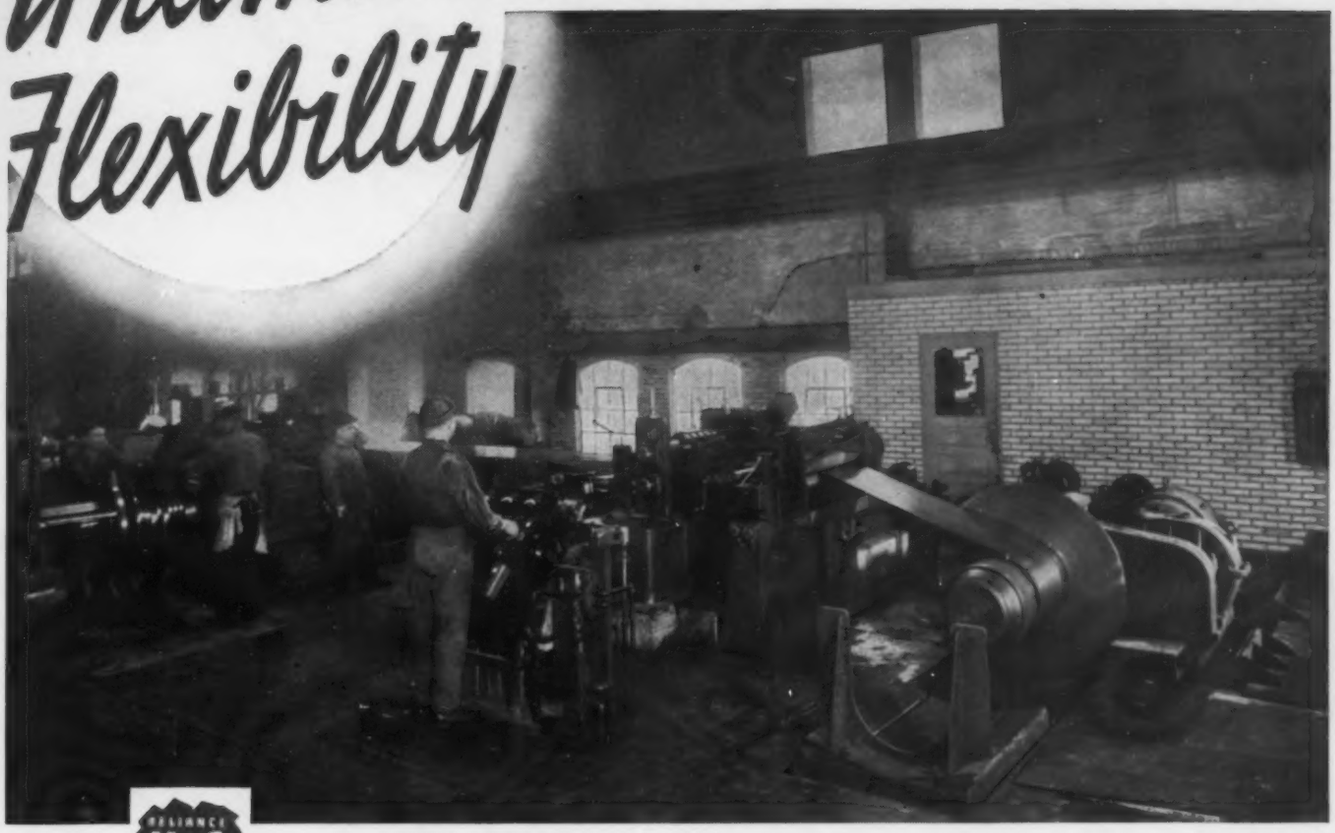


Dowell service is supervised by trained engineers using carefully selected liquid solvents and special mobile equipment.

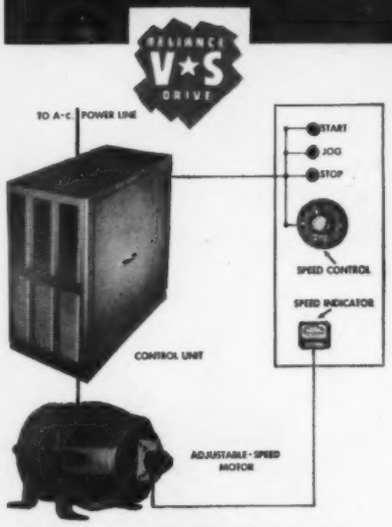
DOWELL

FOR INDUSTRIAL CHEMICAL SERVICE

Unlimited Flexibility



Unlimited flexibility of control is provided by the V★S system for this Silicon Steel Slitting Line.



Conveniently-packaged, space-saving V★S Drive are available from 1 to 200 hp.

. . . with Reliance V★S Drive

Such functions as quick, smooth starting and stopping, stepless speed changing, maintenance of proper tension, and reversal at any point desired are handled by this *All-electric, Adjustable-speed Drive* right from your plant's A-c. circuit. Through automatic or manual control—at the machine or from remote stations—Reliance V★S Drive brings *unlimited* flexibility to any processing operation. Thousands of installations are proving every day that V★S on the job means greater production and lower costs. That's why it will pay you to write today for Bulletin 311 which contains more important facts about V★S Drive.

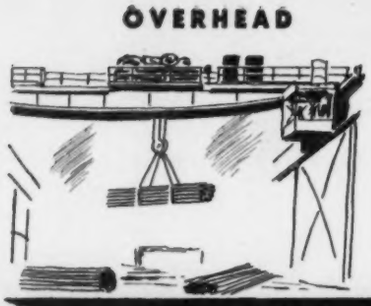
RELIANCE ELECTRIC & ENGINEERING CO.

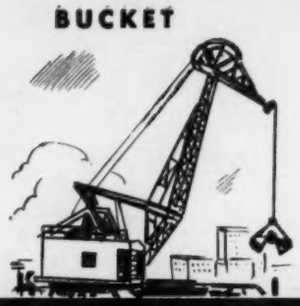
1084 Ivanhoe Road **Cleveland 10, Ohio**

Appleton, Wis. • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Dallas • Denver • Detroit • Gary • Grand Rapids • Greenville, S. C. • Houston • Kansas City Knoxville • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Philadelphia • Pittsburgh • Portland, Ore. • Roanoke, Va. • Rockford • St. Louis San Francisco • Seattle • Syracuse • Tampa • Tulsa • Washington, D. C. • Sao Paulo, Brazil

RELIANCE A-C D-C MOTORS

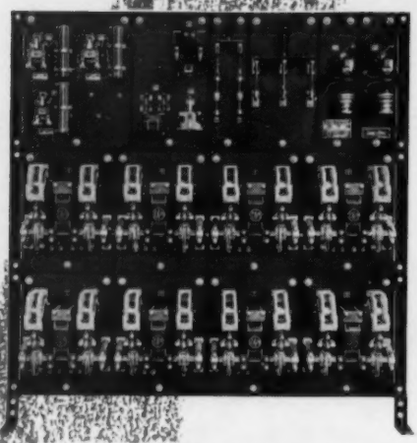
"Motor-Drive is More Than Power"





COMPLETE ELECTRICAL CONTROL

FOR ALTERNATING CURRENT CRANES



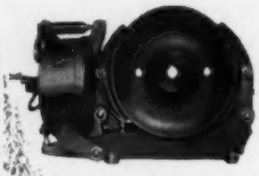
Moving loads quickly and spotting loads accurately are two of the many features which have made EC&M Magnetic Control famous wherever a-c cranes are used. Bulletin 930.

For many years, EC&M has led in the development of extremely sturdy, highly efficient electrical equipment for cranes . . . equipment that meets the requirements of good cranes.

EC&M engineers have designed into this equipment that extra margin of safety and quality which insures uninterrupted service . . . which also includes features appreciated by maintenance men and operators as aids in their daily tasks.

Many users recognize the symbol, EC&M, as a standard of value and specify this equipment whenever new cranes are purchased or when revamping existing installations. These users know that control, only a small part of the initial cost, is a vital part of every crane.

They know, too, by experience, it pays to standardize on EC&M Control for cranes.



To stop and hold the load, EC&M Brakes solve the a-c brake problem. Rectifying equipment is usually mounted on the magnetic control panel. Optional arrangement is in a compact enclosure for separate mounting. Bulletin 1006.

To prevent overhoisting, enabling the operator to do better work by removing the fear of an accident from his mind—Youngstown Safety Limit Stops. Bulletin 1032.

Crane protection—a single unit containing overload relays, knife switch and push-button-operated main line contactor. These Protective Panels provide low voltage protection to the entire crane and permit disconnecting power to all motors in an emergency. Bulletin 1022.

Speed control master switches — cam type and of narrow width to permit close mounting of several in front of the operator within easy reach. Short throw from off to full-on position reduces motion by the operator. Bulletin 1190.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79th STREET • CLEVELAND 4, OHIO

Mesta Machine Company Photo

Use *Texaco Meropa Lubricants* to protect enclosed reduction gear drives. They have more than ample load-carrying capacity for even the heaviest service . . . cling protectively and persistently to the gear teeth . . . resist oxidation and thickening . . . and do not foam.

There is a complete line of *Texaco Meropa Lubricants* to meet the needs of every type, size and speed of enclosed drive — even heavy-duty worm gears — where extreme pressure lubricants are required.

In addition, *Texaco Meropa Lubricants* prevent bearing corrosion . . . and will not separate in service, storage or in centrifuging.

First step towards the extra protection *Meropa* will give your gears is to call the nearest of the more than 2500 Texaco distributing plants in the 48 States, or write:

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO Meropa Lubricants

FOR STEEL MILL REDUCTION GEARS

Tune in . . . TEXACO STAR THEATRE presents the NEW TONY MARTIN SHOW every Sunday night. See newspaper for time and station.

BEFORE YOU BUY ANY MOTORIZED HANDTRUCK

Only Transporter GIVES ALL THESE MONEY-SAVING FEATURES!

1. **ONLY motorized hand truck that comes COMPLETE with Standard BATTERY for full day's operation.**
   Benefit: No extra price to pay for battery. Low overall cost of installation including charger. Compare these prices.
2. **THE motorized hand truck whose battery can be charged from a REGULAR ELECTRIC LIGHT SOCKET.**
   Benefit: No installation cost for charging equipment . . . No power line needed. Fully portable . . . charge your Transporter where it works.
3. **THE motorized hand Truck equipped with EITHER electric lift or foot lift. (Optional).**
   Benefit: The right unit for the right application.
4. **Operates at lower cost than ANY OTHER motorized hand truck.**
   Benefit: Pays for itself quicker than any other motorized hand truck.
5. **No complicated control system to manipulate! Easy two-button Thumb-Tip control with foot lift—3 buttons with electric lift. No controls in handle grips.**
   Benefit: Simple one hand, one motion operation, with either hand.
6. **Operator controlled lowering speed.**
   Benefit: Load can be lowered at desired speed; fragile or heavy goods.
7. **Positive Mechanical Brake.**
   Benefit: SAFETY. Most effective brake on any motorized hand truck. Will stop and hold on any incline truck will climb, by raising or lowering handle.
8. **Positive Dead-Man Control.**
   Benefit: SAFETY. When hand is taken off steering handle, it flips back, Transporter stops dead, and current is shut off in two places.
9. **Only motorized hand truck and battery charger that carry the Underwriters Laboratory Seal.**
   Benefit: SAFETY. Neither truck nor charger is a fire hazard.
10. **No grounded circuits.**
    Benefit: SAFETY. Operators need not fear electric shocks.
11. **Light weight, yet engineered and built for full capacity loads.**
    Benefit: More Power per weight ratio than any other motorized hand truck. No oversized battery to carry.
12. **Maximum accessibility to all operating parts.**
    Benefit: All operating parts can be immediately exposed for inspection, adjusting and lubrication. No boxed-in construction.
13. **Steers through more than 180 degrees.**
    Benefit: Easily maneuverable in narrow aisles, close quarters.
14. **World's MOST EFFICIENT—proved by thousands of Transporters now in use in every industry—many more than ALL OTHER motorized hand trucks COMBINED!**
    Benefit: To labor for lightening life's loads—and to management for CUTTING HANDLING COSTS IN HALF!

BUY ON A "SHOW-ME" BASIS OF MONEY-SAVING ADVANTAGES!

MAIL COUPON!

Transporter
A PRODUCT OF AUTOMATIC
Lightens LIFE'S LOADS

ONLY AUTOMATIC MAKES THE TRANSPORTER

MANUFACTURERS OF THE FAMOUS TRANSPORTERS, TRANSTACKERS AND SKYLIFT ELECTRIC TRUCKS

AUTOMATIC TRANSPORTATION COMPANY
DIV. OF THE YALE & TOWNE MFG. CO.
47 West 87th Street, Dept. H-7, Chicago 20, Ill.

- ☐ Please send the "SHOW-ME" PLAN to check motorized hand truck values.
- ☐ Have an ATCO Specialist make a free survey of my material handling costs.
- ☐ Schedule me for a showing of ATCO'S new film "Pay Loads Pay Off."

Company Name.....
By.....
Street Address.....
City.....*State*.....

Question: What type of electrical cable for all-around service is being widely used in metal-producing and other industries?

Answer: *Okolite-Okoprene* cables, both single conductor and multi-conductor.*

Question: What kind of performance can be expected of Okolite-Okoprene cables?

Answer: *Millions of feet have been installed over the past 20 years and have proved long-lived.*

Question: Where may Okolite-Okoprene cables be installed?

Answer: *In ducts, or buried directly in the ground, or exposed to the elements.*

Question: Is additional protection needed?

Answer: *No.*

Question: What are some of the advantages contributed by the design of Okolite-Okoprene cables?

Answer: *Absence of tapes, braids or metallic coverings that rot or corrode. Perfectly-centered conductors. Uniform thickness of insulation and of covering. Uniform vulcanization throughout entire cable length.*

Question: What are some of the electrical operating advantages of Okolite insulation?

Answer: *High dielectric strength and moisture resistance. Stable characteristics. Low specific inductive capacity. High current carrying capacity. (75°C. copper temperature.)*

Question: What electrical characteristics are contributed by Okoprene, an Okonite-developed neoprene compound?

Answer: *Additional dielectric strength. Additional ozone resistance. High surface resistance which eliminates charging current drainage from cable surface.*

Question: What physical properties of Okoprene provide operating advantages?

Answer: *Lasting weather-resistance. Resistance to oil and solvents. Resistance to acids, alkalies and corrosive chemicals. Non-flammability.*

Question: How about installation?

Answer: *Okolite-Okoprene cables are simple to handle, splice and terminate. They require no potheads. They resist abrasion, are flexible at low temperatures.*

Question: Where can I find out more about Okolite-Okoprene cable and its relation to my problems of electrical distribution?

Answer: *By talking things over with a representative of The Okonite Company, Passaic, New Jersey or writing for Bulletin OK-2009.*

*U. S. Pat. No. 2,312,058

FURNACES LOSE NO HEATING-UP TIME WITH MICROMAX ELECTRIC CONTROL

Left — Steel wire, feeding into a tempering furnace for prompt and accurate heat-treatment which is one step in producing John A. Roebling's Sons Oil-Tempered Spring Wire.

Right — Micromax Electric Control Pyrometers help Roebling's production in two ways — they bring furnaces up to working heat without losing time, and they hold correct temperature in spite of load changes.

One of the many useful features of a Micromax Electric Control Pyromenter is that it not only holds temperature constant after a furnace is hot, but also speeds the heating-up part of the cycle — without overshooting the working temperatures!

Batch processes of course profit most by this Micromax ability. We call it the Rate of Approach feature, and suggest you look into it for the following reasons:

Rate of Approach saves operator's time because no operator has to watch over the heating-up of the furnace. Micromax automatically brings furnace to exactly the pre-determined temperature.

Fast heating plus no overshoot speeds the furnace's heating-up time; also speeds up any change of control temperature.

Prevention of overshoot improves quality of product.

Any L&N Field Engineer will be glad to show you how this and other Micromax features apply to your plant conditions. Or, if you wish, we'll send Catalog N-33A. Address Leeds and Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pennsylvania.

A few coils of Roebling Spring Wire, piled near Furnaces after Micromax-Controlled Heat-Treatment.

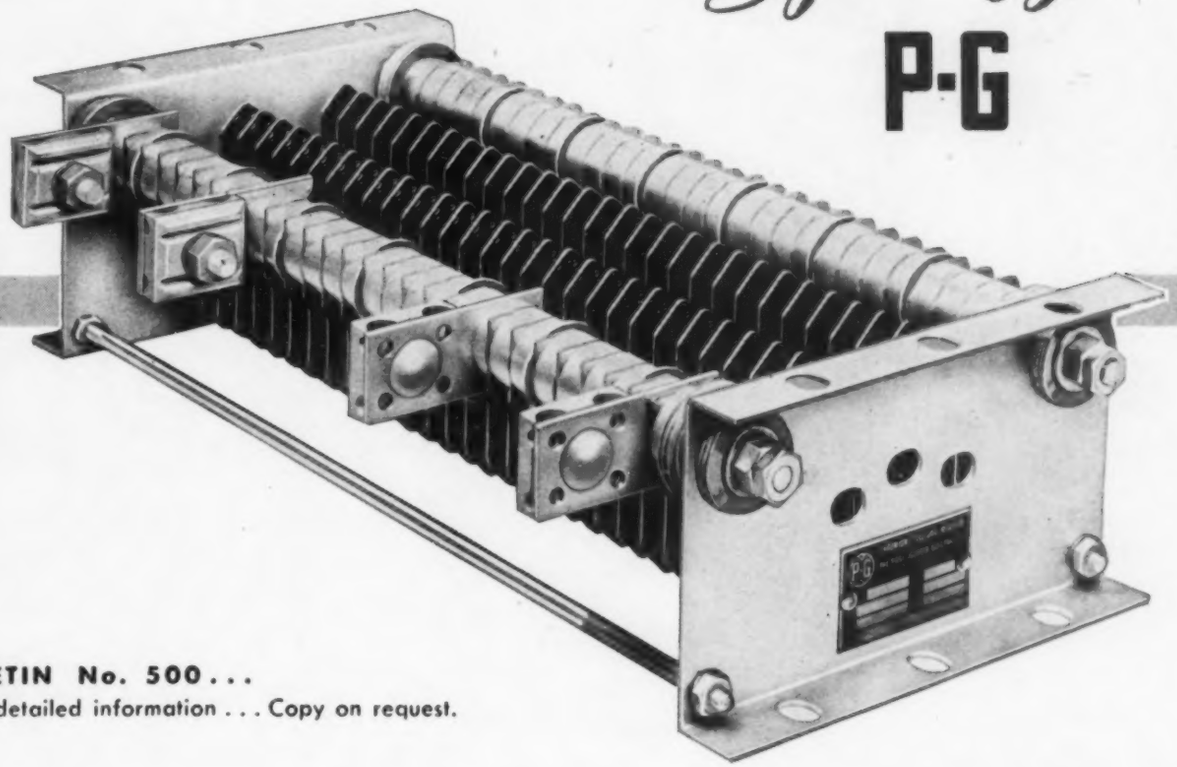
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Ird. Ad N-33A-620(3)

for any job...

WHERE CONSTANT "TROUBLE-FREE" RESISTOR SERVICE IS ESSENTIAL..... *Specify* **P-G**



BULLETIN No. 500...
Gives detailed information . . . Copy on request.

Use of alloy steel and mica insulation, coupled with exclusive features of design, make P-G Resistors capable of constant "trouble-free" service. Specify P-G for maximum production with minimum maintenance.

P-G

The Nonfreezable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

Mass Lubrication for Mass Production

POSITIVE LUBRICATION in Seconds with Oil or Grease

SIMPLICITY and Economy of Installation

SALES OFFICES & ENGINEERING SERVICE from Coast-to-Coast

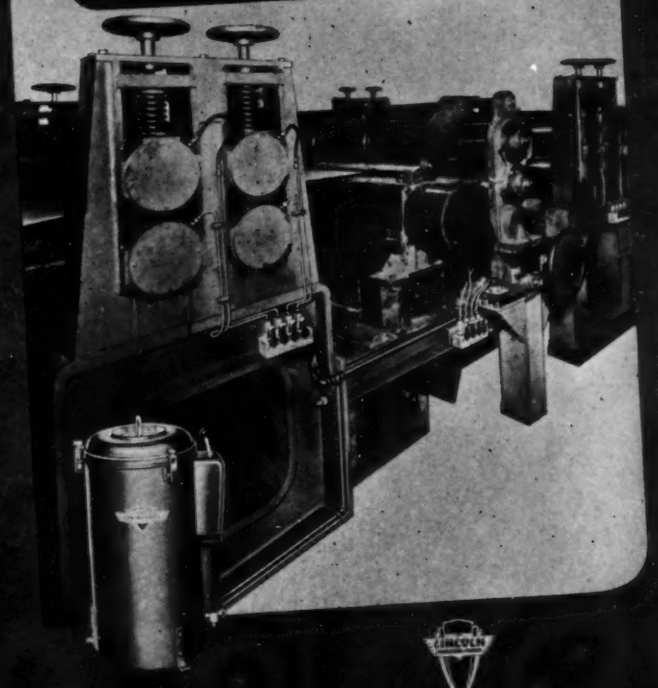
BULLETIN No. 801

LINCOLN CENTRO-MATIC LUBRICATING SYSTEMS

for MASS LUBRICATION

WITH SERIES SL-3 INJECTORS

AUTOMATICALLY CONTROLLED—MANUALLY TIMED



LINCOLN ENGINEERING COMPANY

5701 NATURAL BRIDGE AVE., ST. LOUIS 20. MO., U. S. A.

Save

BEARINGS • MACHINE HOURS • MAN HOURS • POWER • and PREVENT ACCIDENTS

In use throughout modern industry, Lincoln Centro-Matic Systems of centralized lubrication have proven to be the most efficient and economical method for "mass lubrication" of industrial machinery. Systems utilize only one lubricant supply line, insuring the most simplified and economical installation possible. Injectors connected by tubing to the bearings, will dispense either oil or grease, and operate by positive displacement. They are actuated by supply line pressure, and discharge lubricant to each bearing *at the line pressure*. Injectors are adjustable externally so that each bearing may receive a predetermined amount of lubricant.

Various types of lubricant pumps and injectors are available to meet specific requirements.

Cut lubrication time and cost—increase production with *proven* Lincoln Centro-Matic Systems.

LINCOLN *manufactures a Complete Line of Industrial Lubricating Equipment*

LINCOLN

Pioneer Builders of Engineered Lubricating Equipment

Send for Your Copy of This *New Bulletin No. 801*

It gives full information on the newest developments in Centralized Lubrication.

Lincoln Engineering Company, St. Louis 20, Mo.

Please give me information on Centro-Matic Systems for (type of machine)_____ Send me your new Centro-Matic Bulletin 801 ☐ Catalog on Industrial Lubricating Equipment ☐.

*Name*_____

*Title*_____

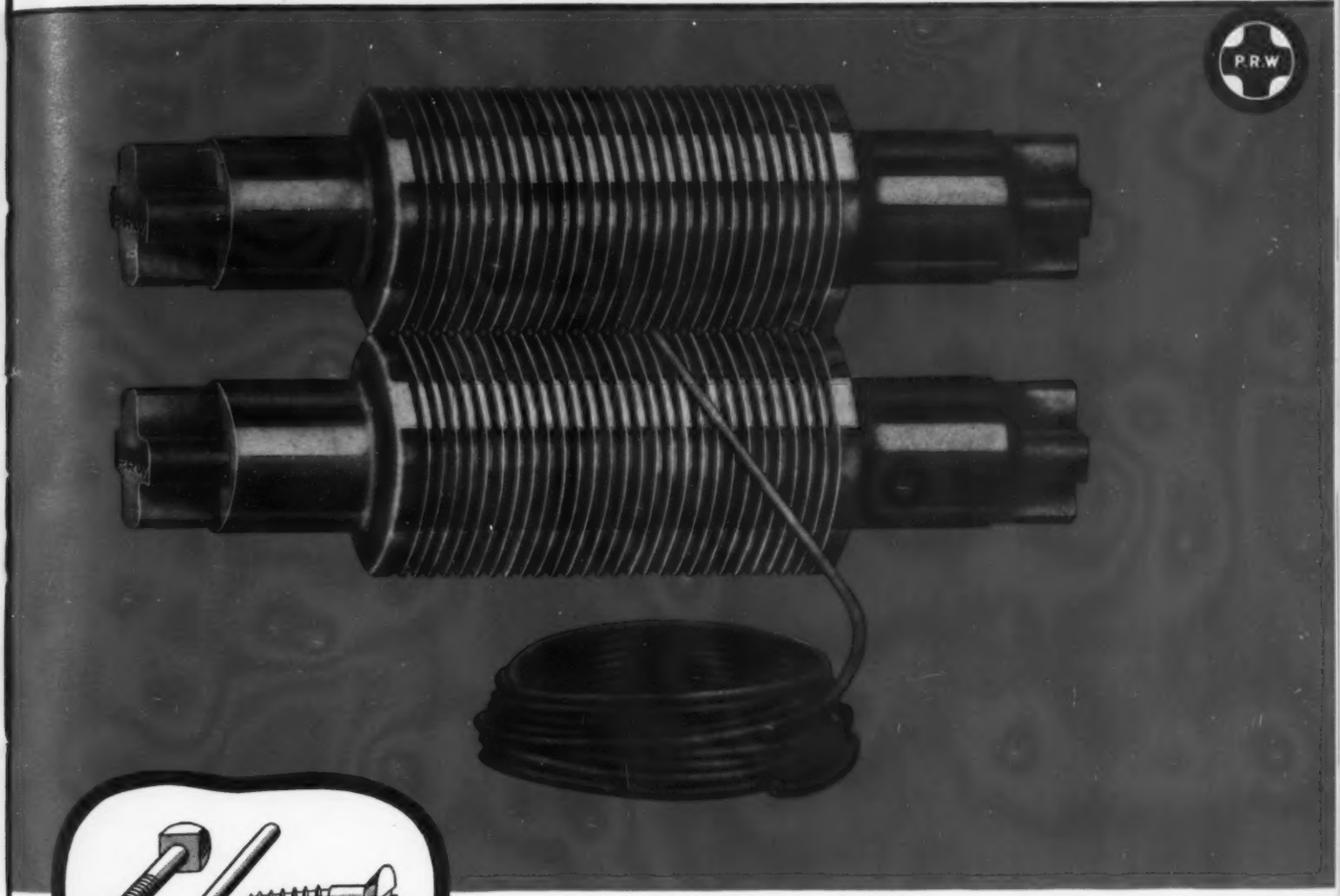
*Company*_____

*Address*_____

*City*_____ *State*_____

847-8

ROLLING TECHNIQUE . . .



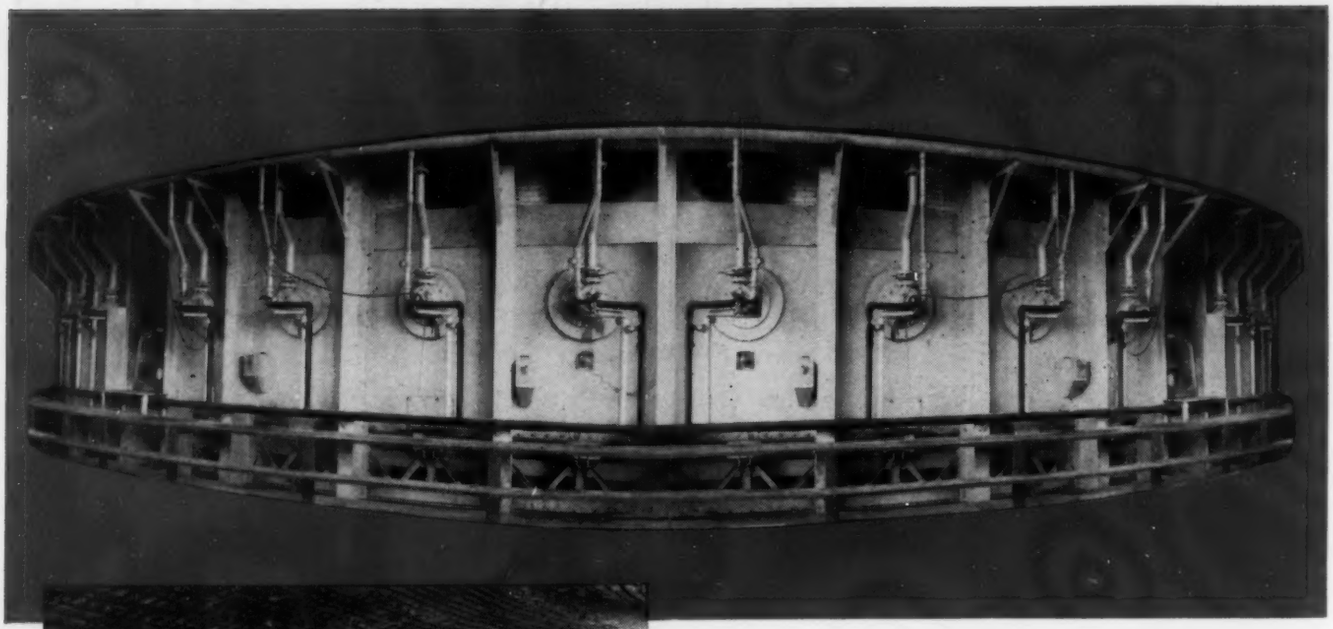
Rods

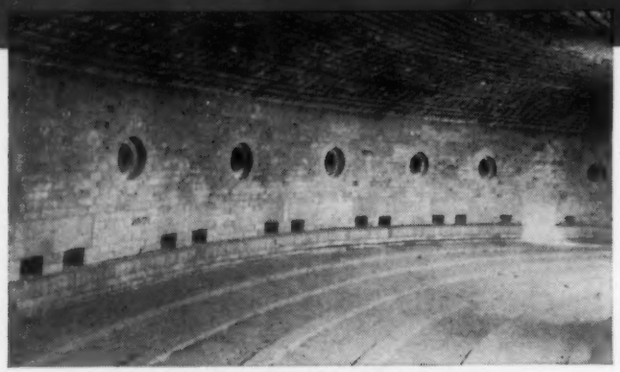
Rod mills, with their ever increasing delivery speeds, require better and better rolls to stand up and give high tonnages of quality rod. Continuous rod mills now in operation are rolling not only steel and numerous alloys but non-ferrous metals as well.

Pittsburgh Rolls, with over three-quarters of a century of roll-making experience and satisfactory performance behind them, can be relied upon to deliver the production of highest quality for which high speed modern mills are designed, at *less cost per ton of steel rolled.*

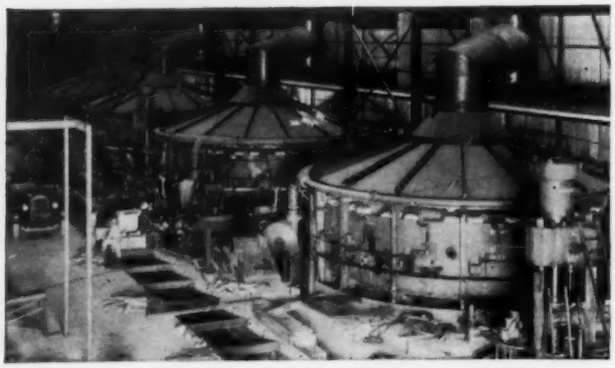
PITTSBURGH ROLLS
Division of Blaw-Knox Company
PITTSBURGH, PA.

PITTSBURGH ROLLS





Inside view after five years' service.



WHY THE WORLD'S LARGEST ROTARY FURNACES ARE SALEM BUILT

On rotary hearth furnaces, hearth alignment—maintained concentric with the furnace chamber—is an important contributing factor to long life and good performance of the equipment.

Salem recognized this fact long ago, and accordingly our engineers developed a special patented feature which is now included on all Salem rotary furnaces. As a result of this new development, the Salem hearth rotates true about adjustable guide rollers, like the outer race of a roller bearing. Complete details and information are available on request.

SALEM ENGINEERING CO. · SALEM, OHIO
SOUTHWEST OFFICE · FORT WORTH, TEXAS
SALEM ENGINEERING CO. (Canada) Ltd., TORONTO
SALEM ENGINEERING CO. LTD., SHEFFIELD, ENGLAND

SALEM

ALL OFFICES STAFFED FOR . ENGINEERING, CONSTRUCTION and OPERATION

Salem Builds

CIRCULAR SOAKING PITS
ROTARY HEARTH FURNACES
CONTINUOUS BUTT-WELD FURNACES
CAR BOTTOM FURNACES
FORGE FURNACES
HEAT TREATING FURNACES
NEEDLE METALLIC RECUPERATORS
AIR RECIRCULATING FURNACES
GAS ATMOSPHERE FURNACES
MECHANICAL EQUIPMENT FOR CHARGING AND DISCHARGING MATERIAL FROM FURNACES

UNITED 16" & 49" x 68"—4-High Sheet Mill

UNITED SHEET MILLS

UNITED mills of the type illustrated are widely used in the cold reduction of both ferrous and non-ferrous metals.

We are now building two similar mills for rolling stainless steel.

Designs of these new units are available for duplication; or they may be modified to suit your requirements.

Why not ask our engineers for further particulars.

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at Pittsburgh, Vandergrift, New Castle, Youngstown, Canton
Subsidiary: Adamson United Company, Akron, Ohio
Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

SHUT-DOWN INSURANCE FOR YOUR FURNACES

Hold shutdowns at a minimum . . . production at a maximum . . . with heat-defying N-B-M Blast Furnace Copper Castings.

- Stack Plates
- Valve Seats
- Mantle Plates
- Bosh Plates
- Tuyeres and Tuyere Coolers
- Cinder Notch Coolers and Monkeys

N • B • M
BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings
Roll Neck Bearings • Slippers
Housing Nuts • Machinery Castings • Babbitt Metals • Acid Resisting Castings
Phosphorized Copper

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
PITTSBURGH • NEW YORK

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

8 BILLETEER BENEFITS
you can't afford to overlook

1

SPEEDS CHIPPING . . . . .
One Billeteer does the work of 10 manual chippers . . . and does it better. No let-up in its speedy, steady output.

2

CUTS LABOR COSTS . . . .
One large user found Billeteer conditioning cost 56% less per ton than hand chipping . . . 39% less than scarfing.

3

BOOSTS WORKER EFFICIENCY . .
The 45 ton weight of the Billeteer takes the punishment of chipping . . . spares the operator from jitters and fatigue common to manual chipping.

4

INCREASES SAFETY . . . . .
490,000 man hours of Billeteer operation and only one disabling accident . . . that's the safety record of Billeteers in one leading steel plant.

5

CHIPS 100% RECOVERABLE . .
Every chip comes clean . . . can be classified according to analysis. Many plants find each Billeteer saves up to 1½ tons of chip scrap a day.

6

SAVES UNSALVAGEABLE BILLETS
The Billeteer's low operating cost permits salvage of badly seamed billets impractical and unprofitable to save by other methods.

7

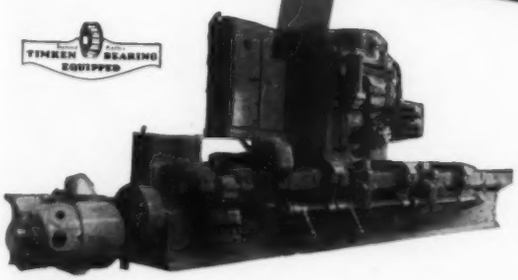
REDUCES BILLET INVENTORY . .
Since otherwise "unsalvageable" billets can be saved it is possible to reduce the required inventory of billets and ingots to a minimum.

8

SPEEDS CRITICAL DELIVERIES .
By permitting reclamation of bad individual billets and even bad heats, it facilitates maintenance of delivery schedules and reduces pick-up items at the melt shop.

PUT THESE BILLETEER BENEFITS
to work for you.

Write today for complete information.



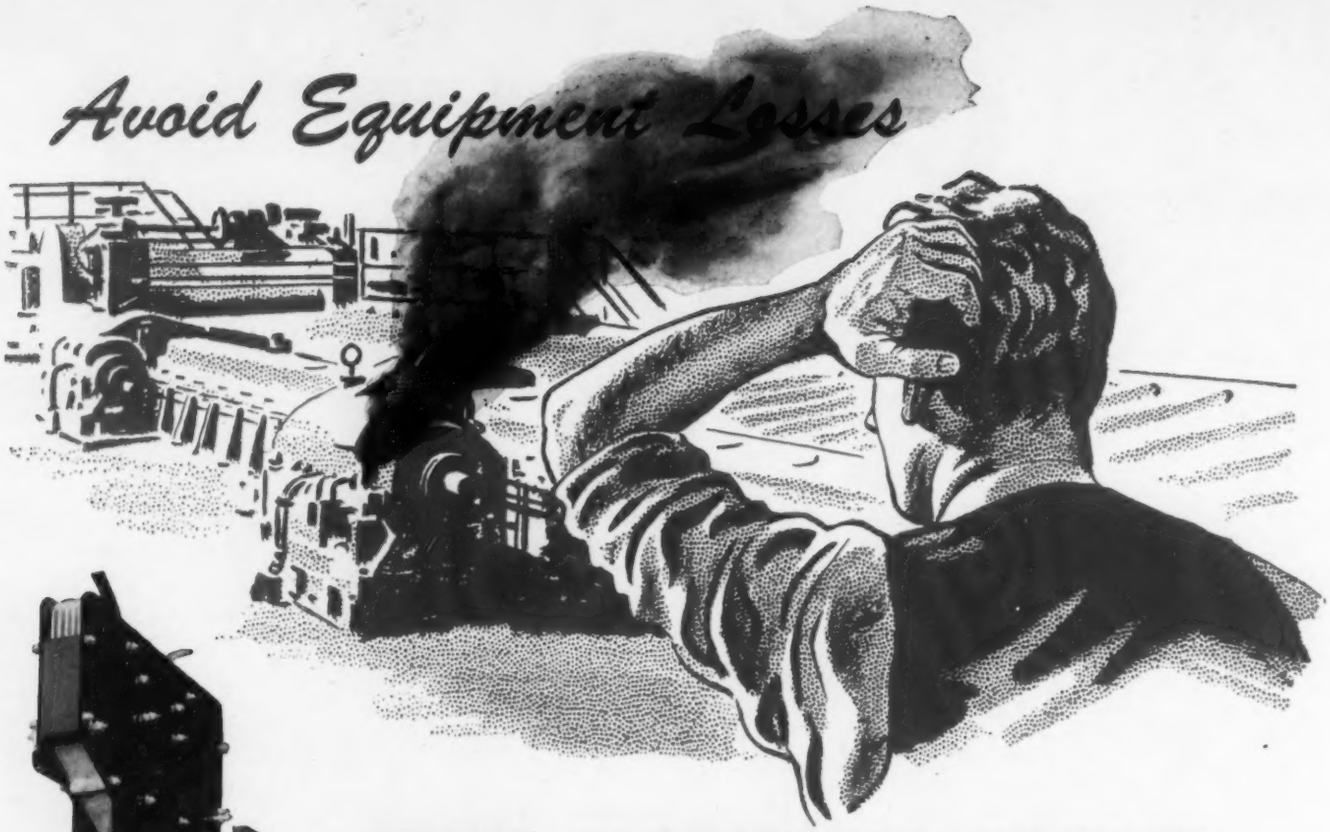
Engineered
FOR LOWER OPERATING COSTS

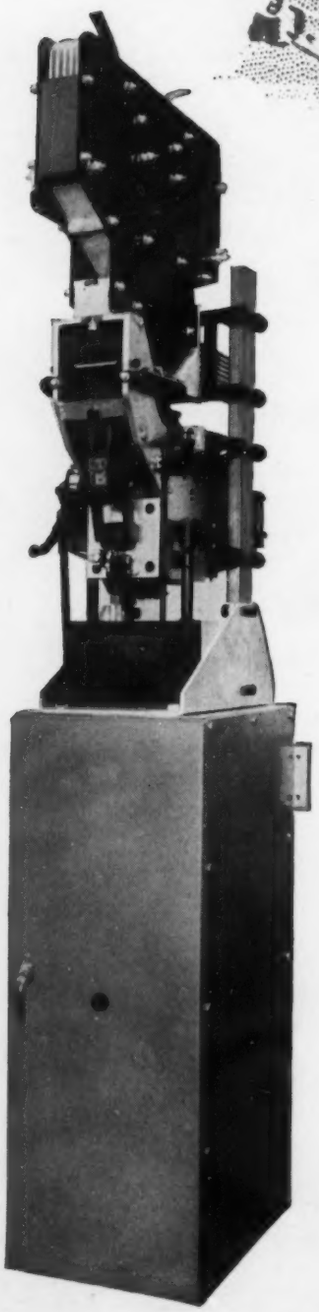
BONNOT

builders of the BILLETEER • THE BONNOT COMPANY • CANTON 2, OHIO

BONNOT BILLET INSPECTION TABLES • CHARGING TABLES • COLD SAW
GRINDING PANS • CLAY MIXERS • CLAY FEEDERS,

Avoid Equipment Losses





FROM ELECTRICAL FAULTS

. . . with the MT Circuit Breaker

The I-T-E Mill Type Circuit Breaker

- Protects valuable equipment from electrical damage.
- Eliminates costly shutdowns.
- Boosts your mill operating profits by reducing maintenance and attendance.

The MT Circuit Breaker confines electrical disturbances to the area in which they occur—minimizing damage and preventing a fault in one area from penalizing another. It differentiates between a useful load of high value and a direct short circuit through the action of the "Rate of Rise" overcurrent trip which prevents unnecessary tripping and resultant production delay.

The tripping devices act directly to open the circuit instantly. The MT Circuit Breaker is mechanically and electrically trip free during the entire closing stroke on overload.

Get complete information on these and the many other features of I-T-E Type MT Circuit Breakers by writing for Catalog 2201, or by getting in touch with your nearest I-T-E representative. I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

I-T-E *The center of Switchgear Progress*

SWITCHGEAR • UNIT SUBSTATIONS BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS

McKAY

BACKED-UP ROLLER LEVELERS

FEATURES

Compact design reduces required floor space.

All adjustments are readily accessible to the operator.

Accurate indicating dials are provided for the screwdowns.

Alloy steel Helical gears are used throughout—fully enclosed and running in oil.

Drive is through Universal couplings.

One-shot lubrication system.

Rugged construction insures continuous performance and low maintenance cost.

The McKAY

Backed-Up Roller Leveling Machine has extraordinary rigidity because its small diameter work rolls are supported by backing-up rolls. This type of leveling works the sheet more thoroughly.

Sheets processed on this type of leveler are strain relieved to a greater extent and have far superior stamping and drawing qualities than those processed by the ordinary leveler.

The McKAY MACHINE Company

ENGINEERS AND MANUFACTURERS OF SHEET, TIN, AND STRIP MILL EQUIPMENT

YOUNGSTOWN, OHIO

ASSOCIATED COMPANY The WEAN ENGINEERING CO., Inc. • WARREN, OHIO

PERFORMANCE
RUGGEDNESS
PRECISION AND
SAFETY

TIMKEN BEARING EQUIPPED SLABBING MILL ROLLS *9,706* NET INGOT TONS IN *24* HOURS!

Number of ingots rolled, 588—one every 2.4 minutes! A record never even approached by any other slabbing mill!

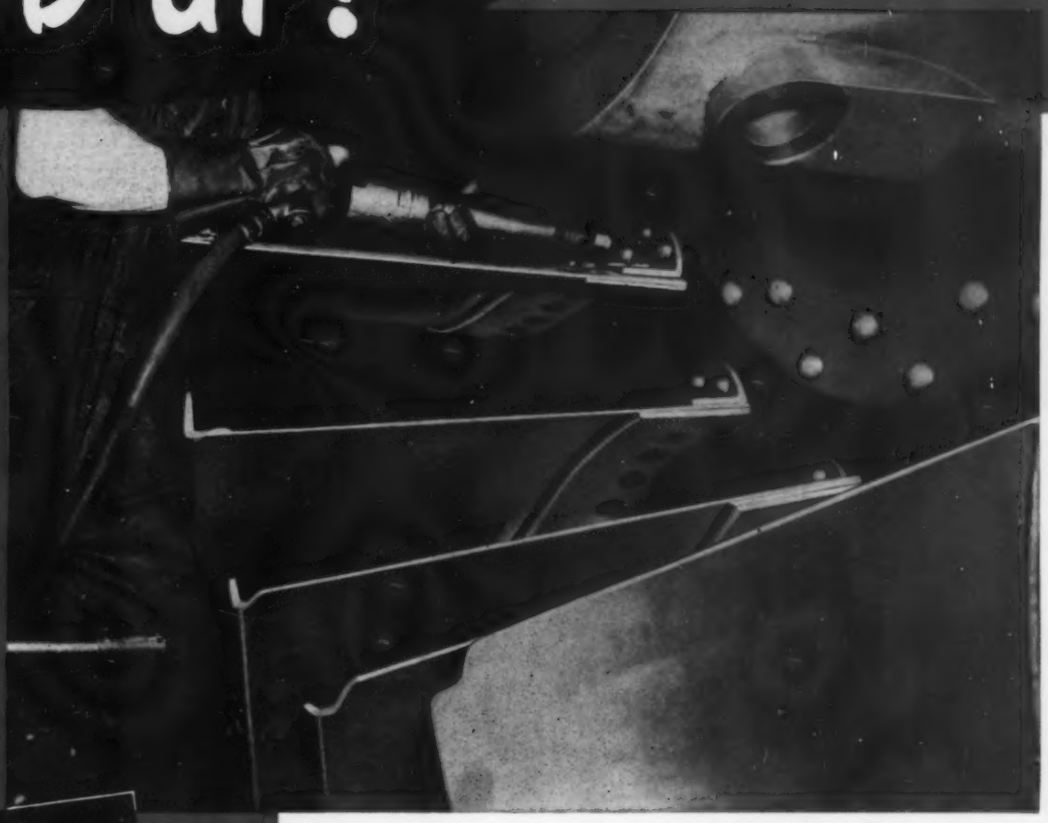
This mill installed in the Pittsburgh district, is the first slabbing mill ever to be equipped with anti-friction bearings. When it went into operation two years ago many in the industry wondered what would happen. But the mill builder and steel operator knew what they were doing and the results amply have sustained their judgment.

For additional information covering the application of Timken Balanced Proportion Roll Neck Bearings in slabbing mills, strip mills, plate mills, bar mills, blooming mills and seamless tube mills consult the mill builders or Timken steel mill bearing engineers. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

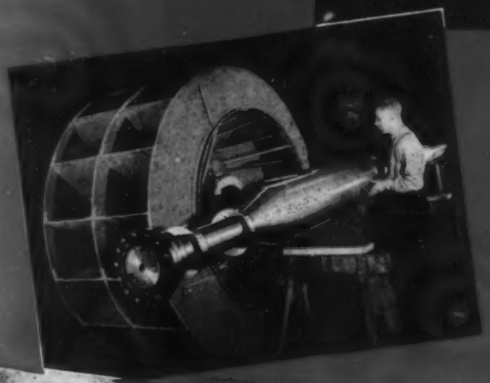
NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬮ AND THRUST →⬮← LOADS OR ANY COMBINATION →✳←

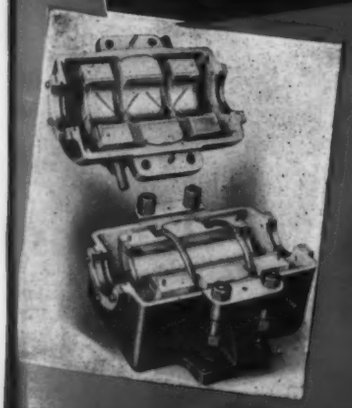
BUILT UP to STAND UP!



Right: "Buffalo Induced Draft Rotors are built for punishment . . . extra heavy-gauge plates and blades hot-riveted together.

Below: Husky, massive, precision - built rotors and shafts mean long, economical service on your draft jobs.





Left: Bearings are self-aligning and water cooled . . . adequate in every respect for smooth running with minimum friction.

Induced Draft fans that stand up far longer under the continual erosion of fly ash and persistent action of gases! "Buffalo" has been building Induced Draft Fans like this for a good many years — and scores of these have been on the job for *decades* with very little time out for repairs.

"METAL WHERE IT COUNTS." Yes, "Buffalo" Induced Draft Fans are "built up" at all points where we *know by experience* excess wear will occur. A look at the rotors, shaft and bearing at left will show you what we mean by "built up to stand up."

ACCESSIBILITY OF PARTS. When a part finally *does* wear out, minimum time is lost in replacing it . . . for all parts are readily accessible.

EFFICIENCY. As in all "Buffalo" Fans, these Induced Draft Fans have precision-balanced rotors and properly formed blades and housings to give maximum efficiencies. *Ask your local "Buffalo" representative for complete data, or write:*

BUFFALO FORGE COMPANY

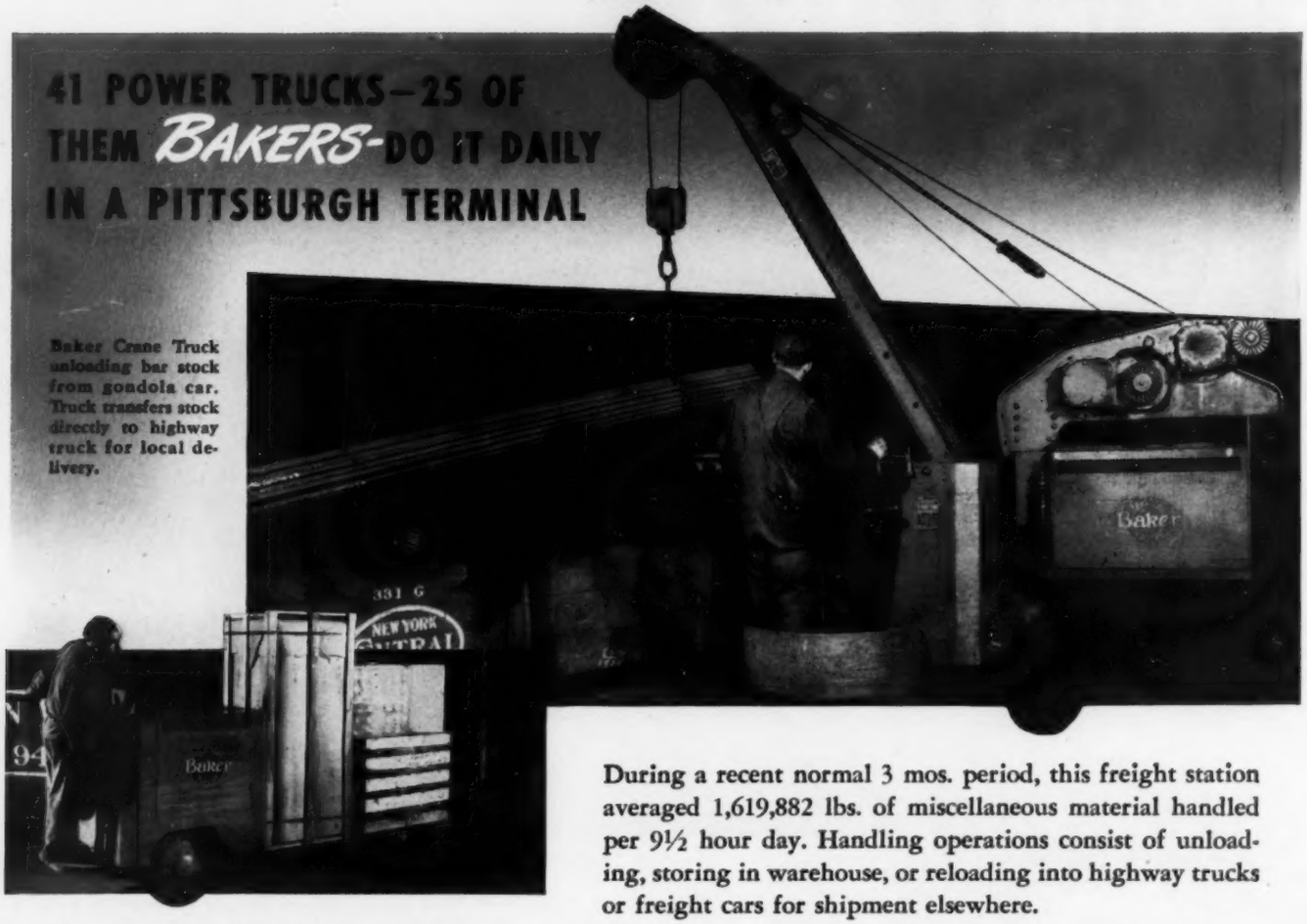
173 MORTIMER STREET BUFFALO, NEW YORK

CANADIAN BLOWER & FORGE CO., LTD., KITCHENER, ONT.

"Buffalo"

DRAFT FANS

Handling 1,619,882 lbs. of freight is a *BIG JOB!*


41 POWER TRUCKS—25 OF THEM BAKERS—DO IT DAILY IN A PITTSBURGH TERMINAL
Baker Crane Truck unloading bar stock from gondola car. Truck transfers stock directly to highway truck for local delivery.
331 G
NEW YORK CENTRAL
Baker

Cartons, crates or boxed materials arriving in box cars are unloaded with Baker Platform Trucks and stored or loaded into other vehicles.

This Baker Platform Truck is taking a load of freight into boxcar for shipment to another station.

During a recent normal 3 mos. period, this freight station averaged 1,619,882 lbs. of miscellaneous material handled per 9½ hour day. Handling operations consist of unloading, storing in warehouse, or reloading into highway trucks or freight cars for shipment elsewhere.

It's not only the tonnage that makes this job tough—but the many different sizes and shapes, degrees of fragility and varying points of destination typical of LCL freight handling.

To help accomplish this tremendous task at low cost the terminal uses 41 battery power trucks—with 21 Baker Platform Trucks and 4 Baker Crane Trucks carrying the major part of the load. The company is eminently satisfied with their efficient performance and reports that even though batteries are charged only once daily, there is *sufficient power to run the trucks the full 9½ hours without slowing down.*

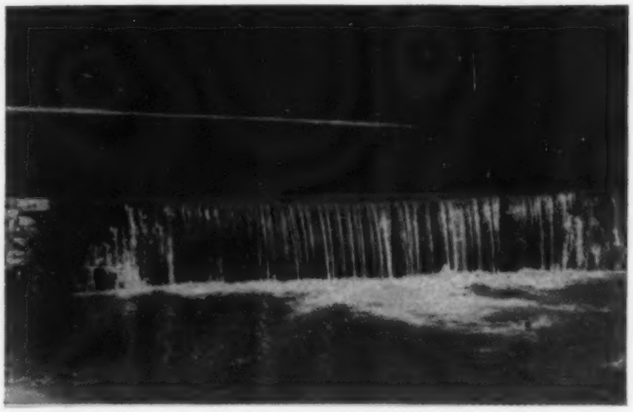
If your problem is handling large quantities of miscellaneous material, Baker Trucks can help you solve it.

BAKER INDUSTRIAL TRUCK DIVISION
of The Baker-Raulang Company
2166 West 25th Street • Cleveland, Ohio
In Canada: Railway and Power Engineering Corporation, Ltd.

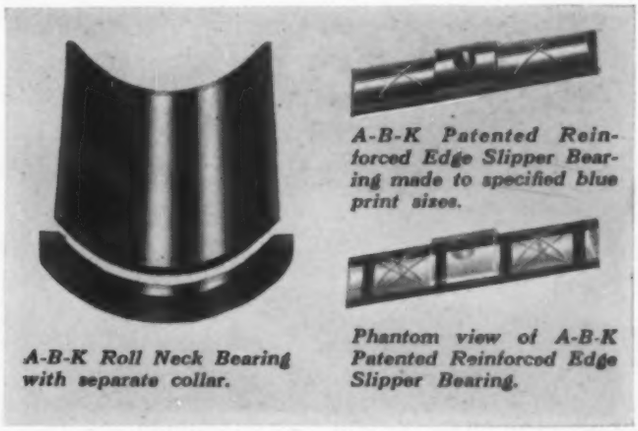
Why are steel mills switching to LAMINATED PLASTIC BEARINGS?*

1. Here's why steel mills are switching to Laminated Plastic Bearings. Records kept by many mills show laminated plastic bearings impressively superior to metal bearings. Investigate these important reasons that stand behind the trend to laminated plastic bearings. One prime consideration is that . . .

2. Laminated Plastic Bearings outwear metal bearings. These bearings customarily have a trouble-free life many times longer than metal bearings. This means fewer shutdowns for bearing replacements. Close tolerances are held with a minimum of roll adjustments. Lost production hours are substantially reduced. Then, too, . . .



3. Lubrication costs are practically eliminated. Water is used to lubricate and cool laminated plastic bearings—no oil or grease. The hard, smooth surface of these bearings, when water lubricated, has an exceptionally low coefficient of friction which results in remarkable power savings. To be sure of these advantages, . . .



A-B-K Roll Neck Bearing with separate collar.

A-B-K Patented Reinforced Edge Slipper Bearing made to specified blue print sizes.

Phantom view of A-B-K Patented Reinforced Edge Slipper Bearing.

4. It is important to specify A-B-K Laminated Plastic Bearings. American Brakeblok Division, American Brake Shoe Company, has designed and engineered A-B-K Laminated Plastic Bearings to take the severest demands of peak production. In service they have proved their ability to make surprising cuts in operating costs.

5. For full information on A-B-K Laminated Plastic Bearings and their applications to your steel mill bearing problems, communicate with American Brakeblok Division, 4600 Merritt Avenue, Detroit 9, Michigan.

American Brakeblok

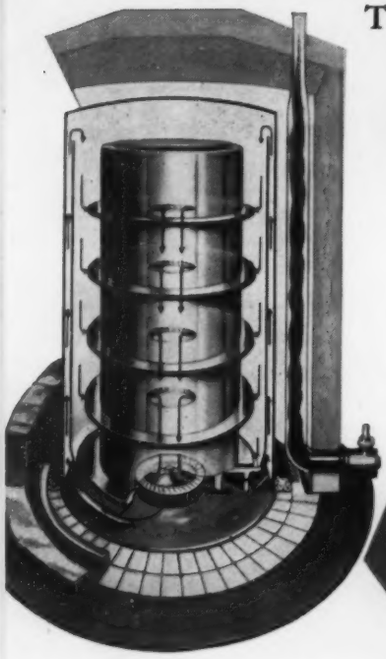
*A·B·K Laminated Plastic Bearings

Brake Shoe

AMERICAN BRAKEBLOK DIVISION • DETROIT 9, MICHIGAN

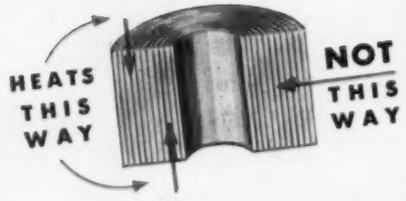
THE

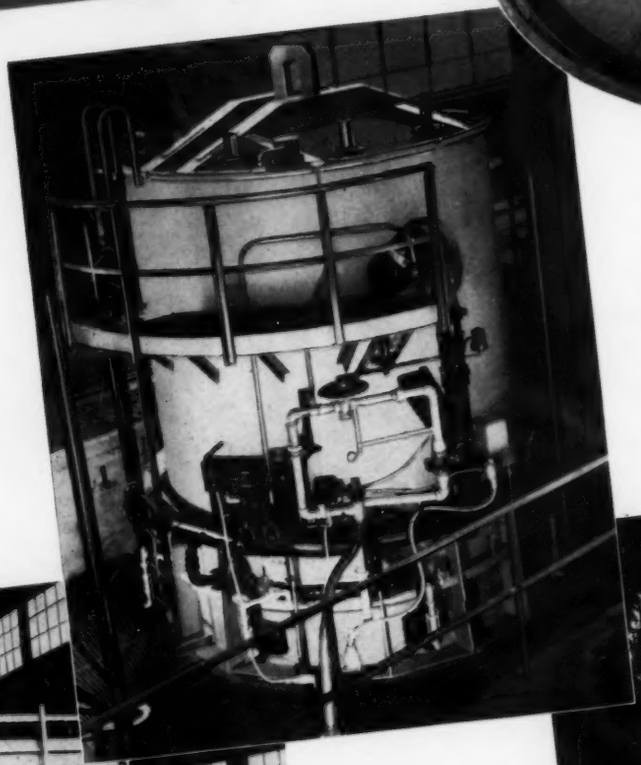
WILSON RADIANT CONVECTOR BELL TYPE ANNEALING *Furnaces*

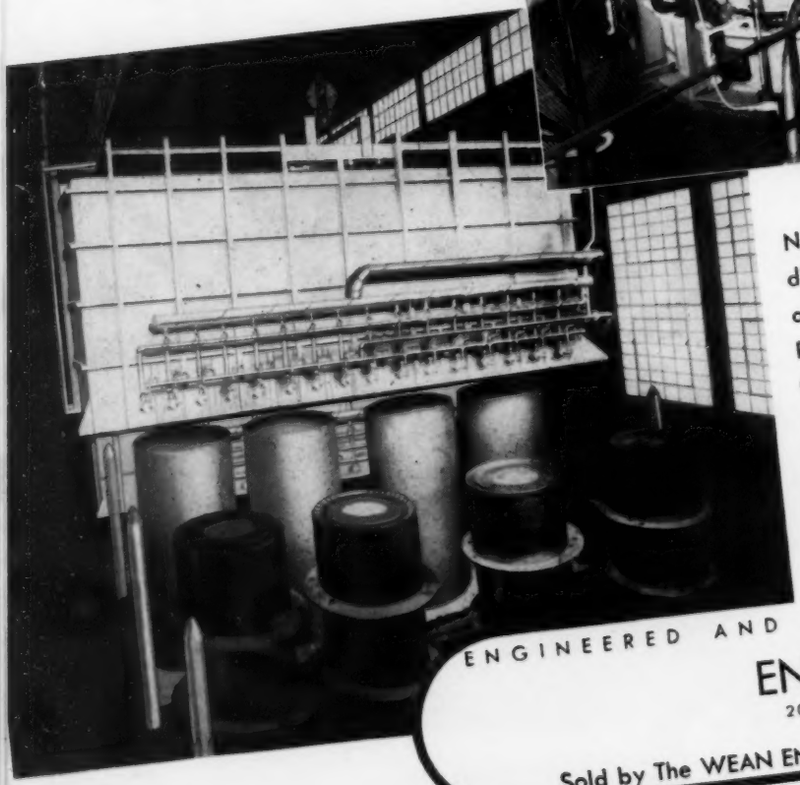


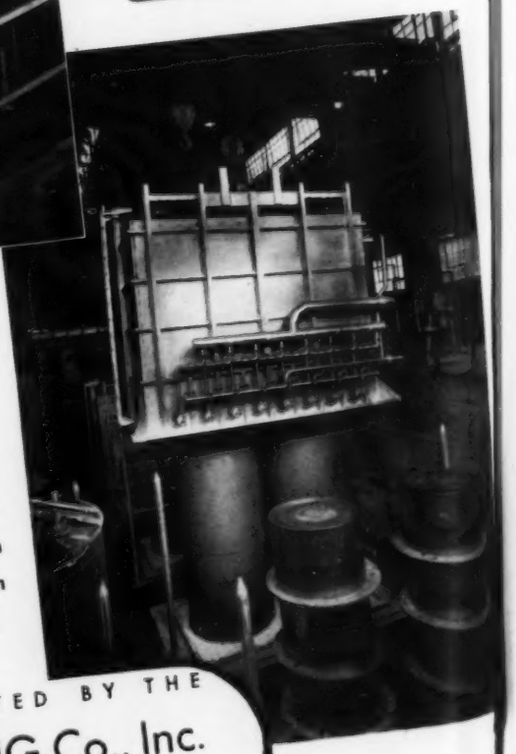
THE PRINCIPLE

THE PRACTICE









No limit on coil diameters. No limit on piling heights. Faster heating. Cooling as fast as heating. One third of normal tonnage in process for a given hourly production.

ENGINEERED AND CONSTRUCTED BY THE

ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

Sold by The WEAN ENGINEERING CO., Inc., Warren, Ohio

* A Family at Work *

THESE Pennsylvania Power Transformers are working for a large Eastern steel mill. Their job is to provide a steady stream of unfailing power to large furnace transformers. To do this job well, they are equipped with over-sized bushings (115 KV) to nullify atmospheric conditions around the steel mills. Two safety valves provide an added measure of protection. Radiators are generously spaced around the tanks to simplify cleaning and painting. The 25,000 Kva transformers are provided with conduits and mountings for the future addition of forced air cooling equipment to increase capacity to 33,333 Kva. Like thousands of other Pennsylvania Transformers, these have worked throughout the war years, and are still on the job giving dependable, reliable service.

Pennsylvania
TRANSFORMER COMPANY
808 RIDGE AVENUE • PITTSBURGH 12, PENNSYLVANIA

Pennsylvania TRANSFORMERS

EASIEST *OF ALL SHEARS* TO OPERATE

"EASIEST of all Shears to operate" are not just our words. They are words of operators being heard with increasing frequency as more Steelweld Shears are placed in plants throughout the country.

Men who have worked for many years on shears of various makes and know them through and through are acclaiming the many features incorporated into Steelwelds — features that ease their work, speed production and make for greater accuracy and minimum maintenance.

Steelweld Shears are entirely new machines designed from scratch as such. They are not a variation of or an adaptation to any previously existing machine. The designers of these new shears were free to incorporate all ideas and features that would result in better machines. They were not hampered by tradition or previous designs or models.

As a result Steelweld Shears are radically different with advantages never before possible.

Whether or not you are in need of a shear at this time, if you work plate in any thickness up to 1¼-inch or length to 18 feet, we urge you to get more data on these modern machines. Keep informed — send for the catalog below.

GET THIS BOOK!

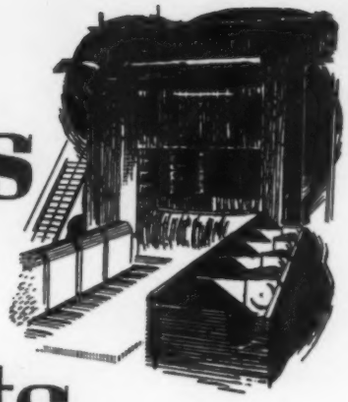
CATALOG No. 2011 gives construction and engineering details. Profusely illustrated.

THE CLEVELAND CRANE & ENGINEERING CO.

5005 EAST 282ND ST. WICKLIFFE, OHIO

STEELWELD PIVOTED BLADE SHEARS

Crops *and* Shorts



NEWS stories recently told of the starting of a new cold mill at Weirton Steel Company with a delivery speed of 5000 feet per minute or more. Just six years ago, when "The Modern Strip Mill" was published by the Association of Iron and Steel Engineers, prevailing delivery speeds of cold mills were considerably lower. In fact, only five units at that time had delivery speeds exceeding 2000 feet per minute, one of which had ventured up to 3750 feet per minute. We believe that the rapidity of this development — and in fact, of the entire continuous strip mill development — may be attributed in no small degree to the open interchange of information on the subject, a major portion of which took place through the pages of the Iron and Steel Engineer.

▲

AS estimated by the American Iron and Steel Institute, combined wages and salaries for the first three months of 1947 were approximately $445,820,000. This figure is for the producing end of the industry alone, and excludes wages and salaries of workers in steel company subsidiaries engaged in other activities.

▲

ONE of our readers suggests that the weaker sex is often the stronger sex because of the weakness of the stronger sex for the weaker sex.

▲

ADDRESSING the National Association of Purchasing Agents, D. F. Austin, vice president of sales for United States Steel Corporation, predicted a balance between supply and demand in most steel products by the end of 1947 if operations are maintained at 90 per cent or more. He ruled out the possibility of lower steel prices and intimated that steel industry earnings in the second quarter will be less favorable than those of the first quarter.

▲

STEEL MILL products rank fifth in value of United States exports for the first quarter of 1947, following grain and grain products, industrial machinery, railroad cars and ships, and automobiles. Steel products are being exported at a rate of $720,000,000 a year, out of a total value of $14,140,000,000 a year for all exports. Canada, South Africa, Argentina, Brazil, Mexico and France are the major buyers.

▲

A CLIPPING from the publication 'Electrical Production,' handed to us by I. N. Tull, announces a visit by the Electrical Maintenance Engineers Association to the Erie works of General Electric Company. The clipping states: "The Erie works produces transportation equipment, ranging from small electric yard locomotives to the electric giants used to haul trains over mountains, refrigerators, and special motors." That may explain the rough train rides we've had lately, but we can't understand, what with shortages and all, why they use such things for road ballast.

▲

ANYONE who thinks by the inch and talks by the yard ought to be moved by the foot, according to Kreolite News.

▲

ACCORDING to Grover C. Neff, president of the Edison Institute, the electric power industry will spend $4,000,000,000 (almost one-third of its present capitalization) on a large construction program to be completed within the next few years. This expansion will be made at very high installation costs, which will tax the earning capacity of the companies.

▲

THE same problem of high installation costs continues to occupy the minds of steel executives. T. M. Girdler and C. M. White informed Republic stockholders that under today's prices depreciation allowances fall far short of the costs of replacement. Replacements, therefore, must be financed in large part from profits or from new capital obtained through borrowing money or selling stock. This may account for the fact that manufacturing companies in general have reduced dividend distribution from approximately 65 per cent of earnings to a new average of about 50 per cent.

▲

IF ALL the sheets which were promised to each other by the chain of brokers, agents and mysterious middlemen uncovered by testimony before the Senate's small business committee were actually available, there'd be no shortage.

▲

BESIDES bringing father's day and a quarterly income tax payment, June marks the anniversary of Ben Franklin's discovery of electricity and Sax's invention of the saxophone. Truly a month of mixed blessings.

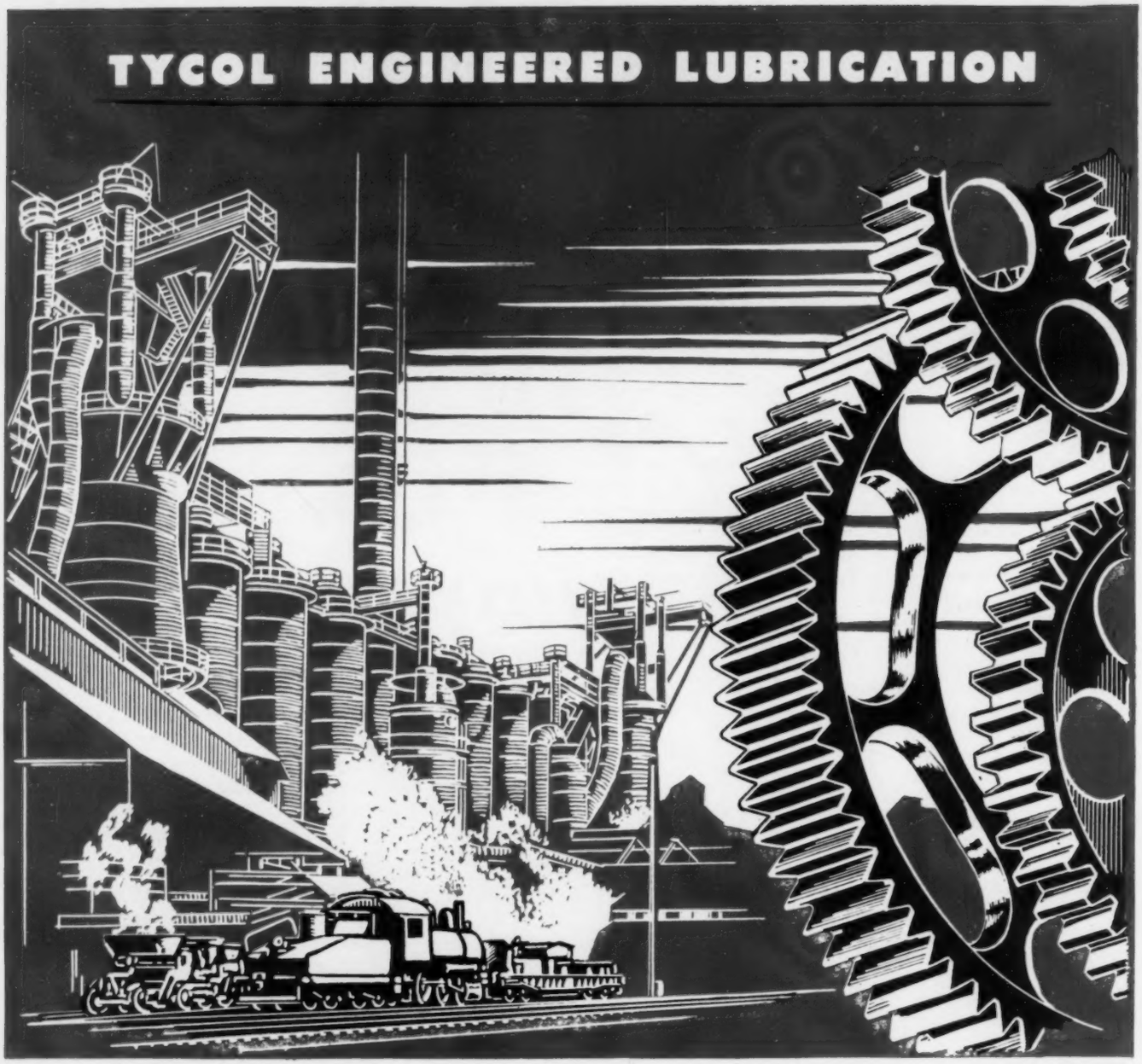
▲

FOR the eleventh time, the C.I.O. has lost a National Labor Relations Board election in major plants of American Rolling Mill Company. Armco workers at the company's two Middletown plants voted 2652 for the Armco Employees Independent Federation, present bargaining agent, 1314 for the C.I.O., and 88 in favor of no union. Of 4400 eligible voters in the bargaining unit, 272 did not vote and 74 votes were challenged by the C.I.O.

▲

A RECENT issue of Trumbull Cheer, house organ of Trumbull Electric Manufacturing Company, offers the following: "The best thing to give to your enemy is forgiveness; to an opponent, tolerance; to a friend, your heart; to your child, a good example; to a father, deference; to your mother, conduct that will make her proud of you; to yourself, respect; to all men, charity."

TYCOL ENGINEERED LUBRICATION



cuts "down time" . . . increases production

TYCOL
INDUSTRIAL LUBRICANTS

Boston • Charlotte, N. C.
Chicago • Detroit
Pittsburgh • Philadelphia
Tulsa

TIDE WATER ASSOCIATED OIL COMPANY
17 BATTERY PLACE · NEW YORK 4, N. Y.

Under all conditions the proved performance of Tycol lubricants more than meets their recommended service.

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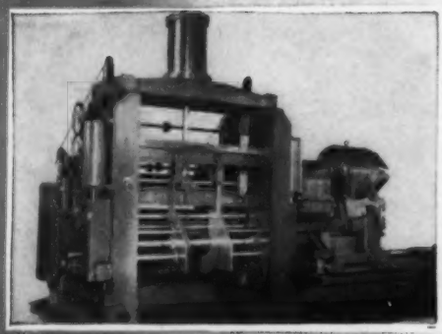

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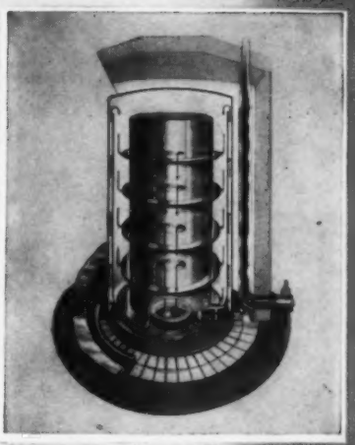

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Iron and Steel ENGINEER

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In This Issue

A New Method of Coil Annealing — by H. H. Armstrong, Vice President in charge of Engineering, and F. F. Schlitt, Combustion Engineer, Lee Wilson Engineering Company, Cleveland, Ohio 35

Discussion: A New Method of Coil Annealing — presented by J. W. Percy, J. S. Stanier, W. H. Dailey, H. V. Flagg, A. J. Fisher, J. Fallon, W. D. Lamont, Victor Paschkis and H. H. Armstrong 40

Heating and Melting Furnace Controls — by C. G. Bigelow, Jr., Assistant Chief Engineer, Furnace Division, Loftus Engineering Corporation, Pittsburgh, Pennsylvania 44

Discussion: Heating and Melting Furnace Controls — presented by John R. Green, John A. Dufault and C. G. Bigelow, Jr. 49

Speed Stability of Motors for Continuous Mills — by F. E. Crever and T. M. Linville, General Electric Company, Schenectady, New York 50

Discussion: Speed Stability of Motors for Continuous Mills — presented by A. L. Thurman, G. E. Stoltz, F. E. Crever and T. M. Linville 58

Machinery for Roller Leveling Flat Rolled Metal — by A. J. Wardle, Jr., Sales Engineer, McKay Machine Company, Youngstown, Ohio 61

Discussion: Machinery for Roller Leveling Flat Rolled Metal — presented by W. D. Shields, Edward W. Voss Company, Pittsburgh, Pennsylvania and A. J. Wardle, Sr., President, McKay Machine Company, Youngstown, Ohio 68

Personnel Selection and Job Training — by W. J. McGlothlin, Chief, Training and Educational Staff, Tennessee Valley Authority 66

Effect of Sulphur Bacteria on Corrosion — by L. Liberthson, Director, Patent Department, L. Sonneborn Sons, Inc., New York, New York 69

Discussion: Effect of Sulphur Bacteria on Corrosion — presented by C. E. Pritchard, E. S. Carmichael and Arba H. Thomas 72

Rod Mills and Rod Mill Roll Design — by Ross E. Beynon, Superintendent, Roll Shop, South Works, Carnegie-Illinois Steel Corporation, Chicago, Illinois 74

AISE Annual Spring Conference Review 106

News Supplement 113

Equipment 113

Personnel 138

AISE New Members 158

Index to Advertisers 171

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A New Method of Coil Annealing

. . . . edge heating of coils, because of the better rate of heat transfer, provides a means of economically annealing the ever larger coils which are now being rolled . . . .

By H. H. ARMSTRONG, Vice President in charge of Engineering
and F. F. SCHLITT, Combustion Engineer
LEE WILSON ENGINEERING COMPANY
Cleveland, Ohio

▲ IT HAS long been known by engineers and operators in the flat rolled industry that it is much easier to drive heat through a pack of flat cut sheets with the edges presented to the source of heat, than it is to drive the heat through the laminations of a coil of strip steel or tin plate. Those long engaged in the process of making flat rolled products are probably familiar with many experiments which have been made to transfer heat to and from coiled sheets from the edges rather than through the laminations. However, until the present time, no practical solution was ever worked out to do this, and in fact, until the present time when the tendency has been to greatly increase the size of the rolled steel coils, no attempt has been made to appraise the problem and reduce the factors to actual values to determine the advantages of edge heating and cooling.

It is the purpose of this paper to discuss a practical solution of this long-standing problem. The word "practical" is used to convey the idea that this discussion is not theoretical but is based on a method which has been reduced to actual practice and is now in use in strip mills with additional units under construction at the present time both in this country and in Canada.

During the war years, the engineers in the steel industry carefully considered improvements in processing which they would put into effect at the cessation of hostilities. The size of slabs used for rolling strip coils had been increased steadily during the years of development in the strip industry to a point where 10,000 to 15,000 pound coils were common. To decrease handling costs and material scrap losses, the engineers investigated the possibilities of making these coils larger and thought in terms of a coil weighing 30,000 pounds and more, with diameters as large as 78 in. and with the furnaces so built that the piling height of the charge would be as much as 160 in.

Their first thoughts on annealing coils of this size were that the vastly increased weight of the charge would more than compensate for the increased hours to anneal, but a survey of this problem indicated otherwise. For, while the coil outside heat transfer surface was increased, it was only by the single power of the diameter, while the mass which had to be brought up to temperature was increased by the square of the diameter. Since no actual figures were available for the cycles required for annealing these large coils, the cycles had to be calculated. The calculated time required to procure an acceptable temperature field by heating through the coil laminations in the ordinary manner, indicated that the time length of the furnace use would be in the neighborhood of 140 hours with approximately twice this length of time required to cool the charge, which means that the coils would be in the annealing process for approximately 2½ weeks' time. Obviously, the tons per hour yield in charges of this nature would be decreased rather than increased, and the total advantages obtained in processing larger coils would be reduced in the annealing process. Consequently it was desirable to conceive a different method of annealing coils of the new large sizes and increased piling heights.

The first step involved in the solution of this problem was an investigation of the theoretical rates of heat penetration through the laminations of the coil as compared to from the edges of the coil.

Figure 1 illustrates graphically the low temperature

Presented before AISE Annual Convention, Cleveland, Ohio, October 2, 1946.

head required to drive heat across a wrap as compared with that necessary to drive it across a gap.

The effect of this gap is shown by the sharp reductions in heat transfer as indicated by the steep angle of the transfer line at this point of the coil.

The effect of radiation between laps is so small as to be negligible when compared with that conducted by the intervening gas. The conductivity of the gas space is likewise quite small when compared with the conductivity rate conducted through metal; so small, that were it not for the microscopic point contacts existing between wraps, the difference in the comparable heat heads would be much greater.

In a coil that is as thick radially as it is wide, the theoretical relation between the rate of transfer from the edges and through the laminations averages 18 to 1, the exact figure depending on the sheet gage. This is determined by the theoretical heat transfer coefficient for solid metal as compared to the theoretical heat transfer coefficient through laminations. Practical determination in some cold rolling mills had indicated that 8 to 1 was a more practical figure, due to the fact that in practical operation, some heat cannot be prevented from entering through the edges in lamination flow tests and vice versa and materially affecting the temperature field.

In tests that were made, the edges were subject to final annealing temperatures when heated, so that a large temperature gradient was established between edge and center almost immediately. The method of procedure necessary to accomplish this is not practical, consequently a compromise was effected which promised a heat transfer rate of 2½ to 4 times greater than could be obtained from the conventional method of heating through laminations.

This was the thesis that was set up to be proved in an actual furnace construction that would be practical enough to use. This increase in yield has been accomplished in a type of furnace that combines the advantages of radiation, convection and conduction of heat, such as is shown in Figure 2, which is a phantom view of a single stack of coils which is being heated by what is called the radiant convector principle.

To all external appearances, this heating unit is identical with the standard type of bell furnace with the exception that the observer would immediately see that the piling height has been increased by a considerable amount and in the multiple stack furnace type, the units would be built in single rows in order to secure rapid cooling as well as rapid heating. The furnace is heated with radiant tubes, an inner cover is used over each stack of coils, and a recirculating fan operates under each stack of coils. The coils are placed on the base platform in the usual manner, but below the bottom coil and between each of the coils above it, there is placed a coil spacer or compensating convector which provides a path for recirculating gases to pass between the edges of the coils in the stack. This is the path through which the heat is delivered by convection to be conducted away by the coil edges toward the center of the coil.

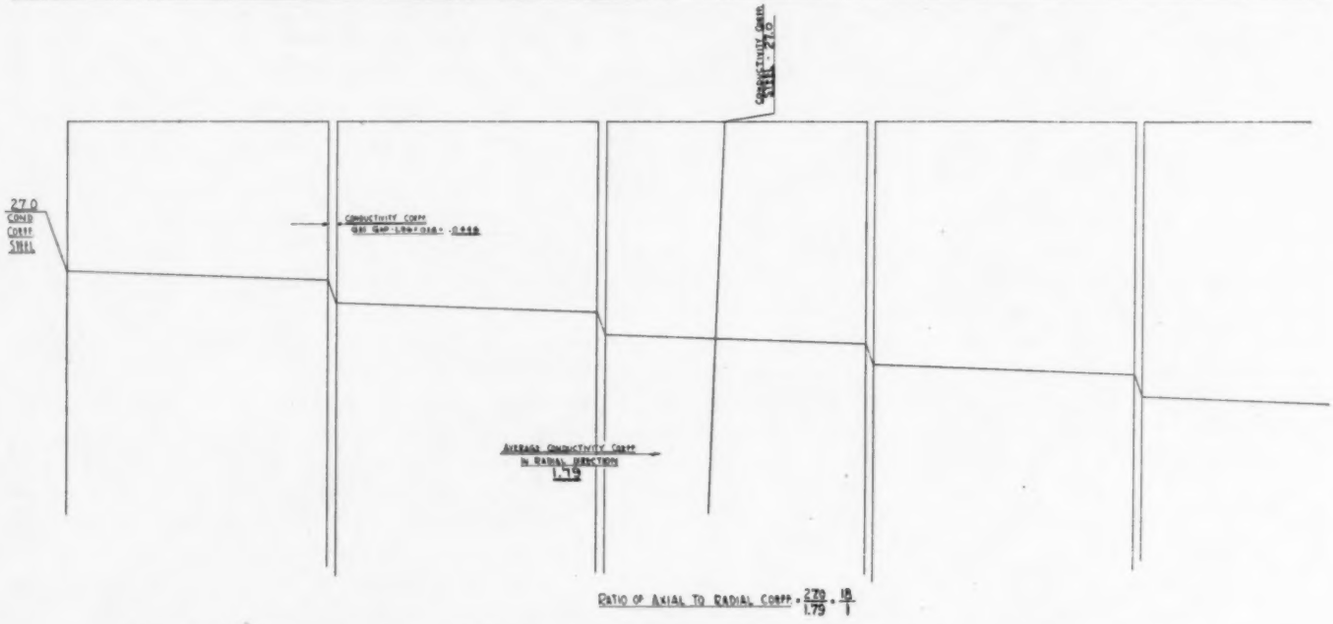


Figure 1 — The air gaps between the wraps of a coil almost act as insulation to prevent heat transfer.

It will be readily seen, if the heat is applied in such a manner, that the rate of heat deposition on the coil edge must be high in order to take advantage of the high conductivity afforded by the through metal path from edge to center.

To do this, the gases are circulated by a high capacity fan with a high static pressure characteristic, and these gases are driven up between the inner cover and an inner liner which provides velocities in the nature of 50 fps at which an extremely high rate of heat transfer can be made by convection. The top hole in the stack of coils is covered with a plate so that the path which the gas must take is down around the outside faces of the coil, through the compensating convectors and then returned to the fan for recirculation. The path that the gases take is really through a pair of heat exchangers in which heat is added to the recirculated gas in one and extracted in the other. Which function each ex-

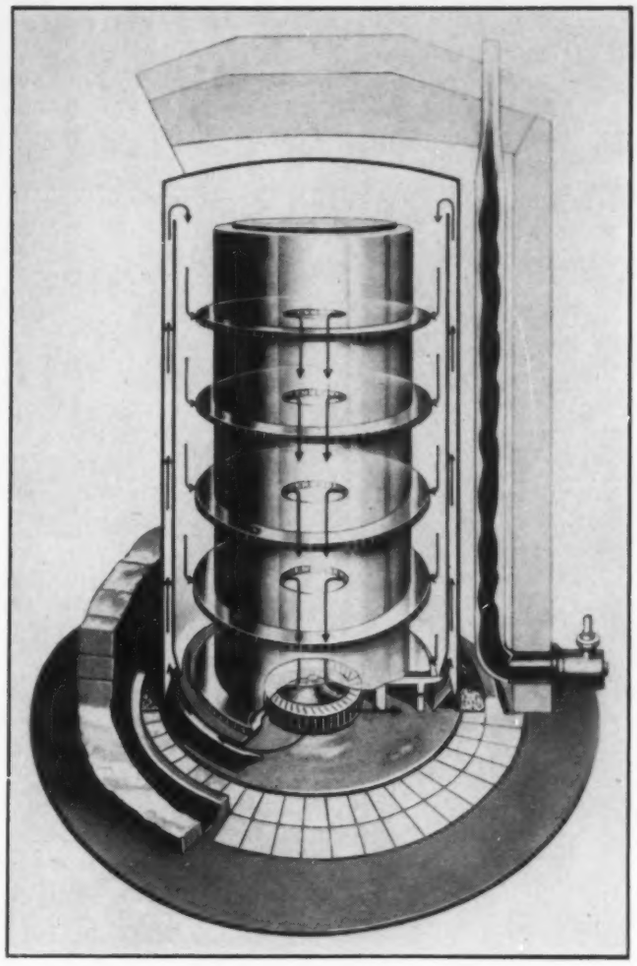


Figure 2 — This phantom view shows a stack of coils being heated by the radiant convector principle.

changer provides depends on whether the charge is being heated or cooled.

After the gas leaves the fan, the total pressure is largely converted to velocity pressure in a vertical direction through a jet at the outer edge of the base plate. This is done to prevent excessive static pressures at the sand seal and consequent excessive gas losses through that seal. Further, it provides a static pressure condition that will enable protective atmosphere to be admitted at the usual pressures of 2 to 3 in. of water.

The velocity is maintained through the inner cover liner but as the gases turn down along the faces of the coils, the velocity decreases and the relative static pressure existing between the outside and inside of the convector vanes is sufficient to permit high mass velocities through the convector vanes and therefore a rapid heat transfer to the coil edges.

In turn, it will be recognized that with the steel being able to absorb the heat quickly and the circulating system being able to take the heat away from the inner cover, more heat must be made available from the radiant tubes. The diameter of the radiant tubes has been increased and burner changes made so that each tube is capable of an input of 500,000 Btu per hour. The type of burner, known as a dual pressure design, permits an adjustment of primary and secondary air so that the length of flame in the radiant tube can be adjusted to be equal to somewhat less than the total length of the tube in the furnace so that the heat transfer is accomplished over a large area and the Btu transfer per square inch is held within safe limits. The type of burner used, which has been in widespread use for a number of years, will operate at a 10 to 1 turndown at full efficiency.

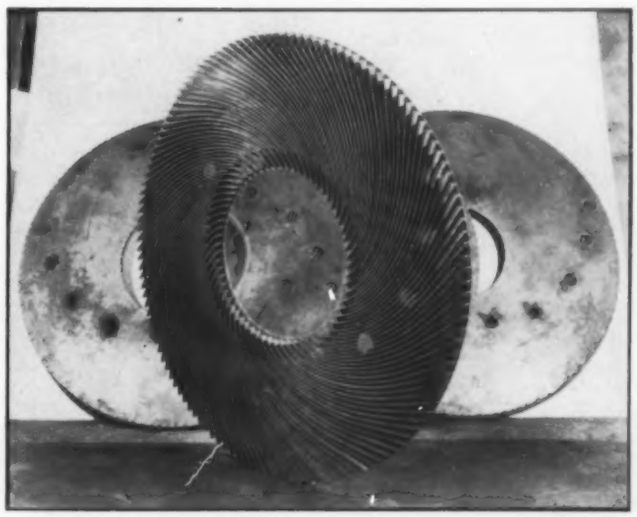
It would be pointed out that with this system of heat transfer not only is the heating time shortened but the cooling time is reduced in the same proportions. After full coil penetration to the uniformity desired, the furnace bell is removed for use on an adjacent base, and then all the elements which contributed to the fast input of heat will also contribute to its removal so that the length of cooling cycle is but very little longer than the heating cycle.

The critical portion of the design of this heat application is the compensating convector, shown in Figure 3. Its function is that of providing means of imparting heat to the coil edges at such rates as will insure acceptable temperature fields in the coils. To do this, it must compensate for the radiant heat supplied the outer wrap and must compensate for the temperature change in the recirculated gas as it passes through the convector. For this reason, the name "compensating convector" has been adopted.

Both the above compensations are affected by the vane shapes which reduce the area of passage and increase the mass velocity of the gas as it flows toward the coil core and at the same time increase the convection transfer surface.

Holes are provided in the top and bottom plates of the convector, so distributed that there is an opportunity for the air between the coil wraps to be removed by aspirating effect of the rapidly moving gases. The vanes of the convector by their curved shape add to the strength of the structure, and while these units are made of mild steel, their life is set at 40,000 hours of service. Actual performance indicates that this figure can easily be met as the convectors show no distortion or tendency to pull apart when used with coils that are anywhere near the size of the convector itself.

Figure 3 — The compensating convector provides heat to the coil edges at the correct rate.



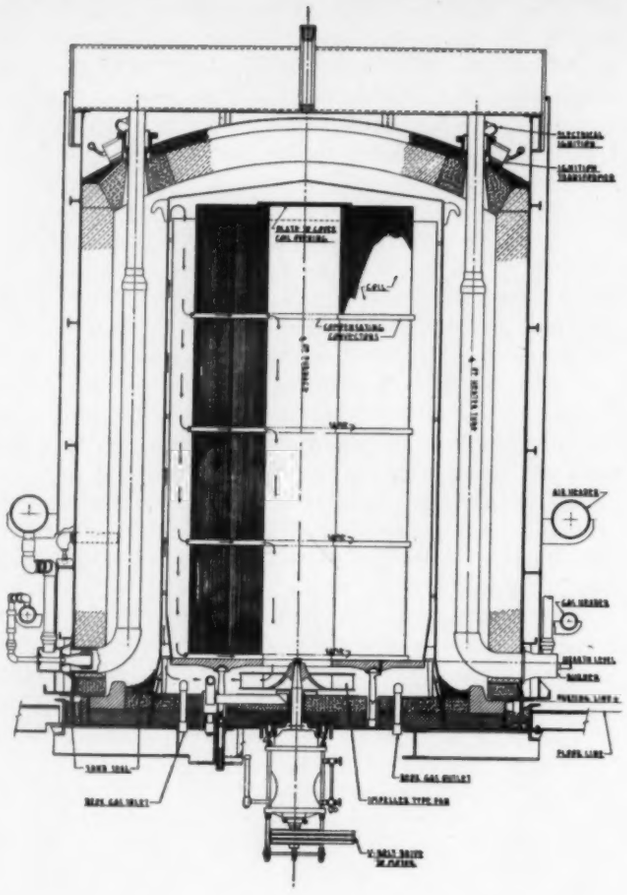


Figure 4 — Cross-section of two stack annealing furnace for 60 in. diameter, 126 in. high coils.

Referring to Figure 4, which is a detailed drawing of the furnace cross-section of one stack of the convector furnace, this picture shows the novel type of patented loading platform construction in which the load on the charge pedestal is transferred to the framework of the base by means of alloy rocker arms so that the platform is not supported by any brick whatsoever. The loading platform itself is a single circular casting with a machine surface which makes it possible for the extremely high piling heights to be used without sticking the bottom coil edges.

In this pedestal is located the centrifugal type fan which is made of 35-15 alloy, mounted on an alloy shaft, which is driven by a 15 hp motor by means of a belt drive. On and around the shaft is provided a rotating liquid seal to prevent the loss of gas or entrance of air along the shaft.

The fan shaft is hollow up to the vicinity of the top bearing, and a small quantity of low pressure air is delivered up the shaft to prevent overheating of the top bearing. This air is delivered from the auxiliary blower which will serve all of the bases in the annealing unit. A standby unit is also provided to guard against failure of the low pressure air system.

The inner cover construction indicates how the inner liner is positioned in place by a series of studs welded to its periphery. This liner is rigidly fastened to the outside seal of the inner cover only at the bottom so that the entire weight rests from the inner liner to the loading platform and does not bear on the bottom edges of the inner cover. This feature of design has contributed largely to the excellent inner cover service of mild steel construction, as the inner covers show little if any distortion even after 30 to 40 heats.

The detailed description given above is to acquaint the engineers and operators of this industry with the detail and care with which this unit has been designed. All of this information is interesting but a new design is measured by what it will do in actual performance and now data can be offered to indicate the net gain of this new type of coil heating.

At the present time there are three operating installations of this unit with a number of additional units under construction. Both single stack and multiple stack units have been constructed and operated. These units have been built for the following charge sizes: 48 in. diameter and 96 in. piling height; 60 in. diameter and 126 in. piling height; and 78 in. diameter and 140 in. piling height. Both liquid and sand seals in single

Figure 5 — A yield of 1.47 tons per stack per furnace hour is shown by this chart.

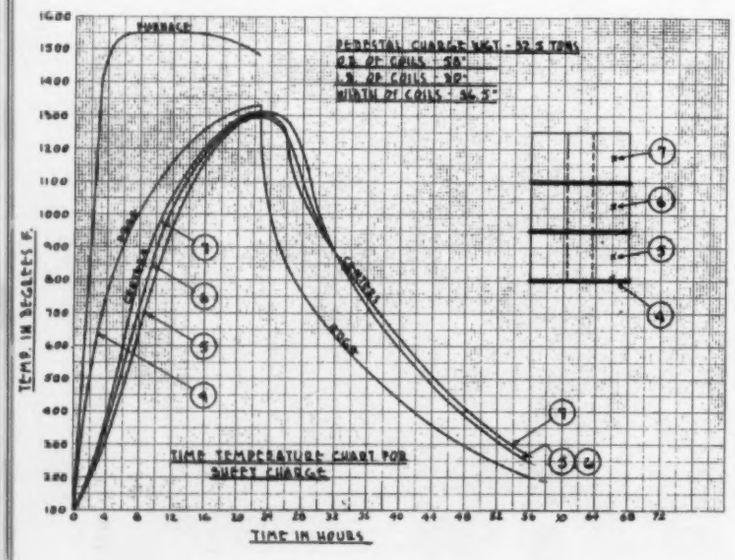
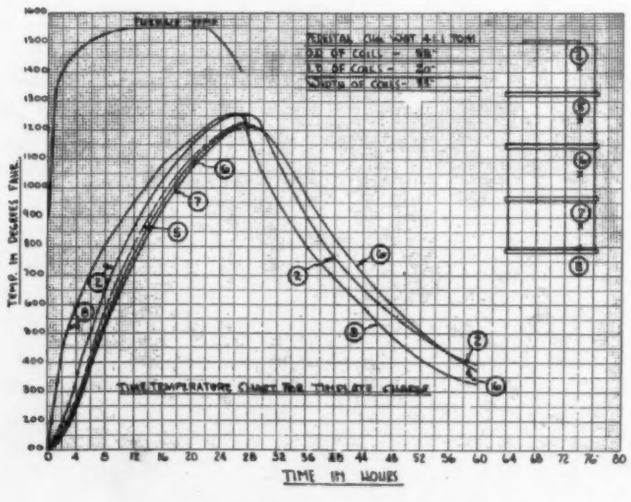


Figure 6 — Temperature distribution throughout stack for tin-plate charge.



stack furnaces and sand seals in multiple stack furnaces have been used.

Test charges of various dimensions as regards coil diameters and piling heights have been run and of these, three will be discussed, namely, a small sheet charge, a medium sheet charge, and a medium tin plate charge. By medium is meant coils well below the anticipated 78 in. diameter, which to date have not been available for test purposes.

A charge of coils 34 in. diameter, weighing only 8 tons per stack, was heated to a specified temperature spread of 35 F between edge and center in 8 hours, for a heating rate of 1 ton per hour per stack. The physical characteristics of the annealed charge compared favorably with those obtained formerly in charges that had had from 20 to 24 hours furnace time. The charge was cooled in 7 hours with the assistance of a forced type cooler which blows air on the inner cover and uses a water spray when the charge is relatively cool, that is, below 600 F. This particular furnace is designed to use double wrapped coils so that the charge weight can be increased with a much smaller proportionate increase in time. As evidence, double wrapped coils have been heated in this unit in 12 hours furnace time.

A second test is that of 58 in. coils piled 109 in. high for a stack weight of 32.5 tons. Figure 5 illustrates the furnace performance so loaded. The specified temperature field was one in which no part of the stack was to be less than 1300 F and that the bottom edge was not to exceed 1350 F. It was accomplished in 22½ hours of furnace time for a net yield of 1.47 tons per stack per furnace hour. As a matter of conservative practice some additional time was added to subsequent charges for a soaking, but even with this, the yield per stack was approximately 1.25 tons per hour.

In determining the furnace performance for tin plate, the stack was 4 coils of 58 in. diameter and weighed 41.25 tons. Figure 6 shows the temperature distribution between the coil centers, and it is to be noted that after 27 hours furnace time, a uniform spread of approximately 40 degrees was established throughout the center temperatures of all coils in the stack. This is equivalent to slightly over 1½ tons per stack per furnace hour.

The advantage of edge heating is emphasized by the comparison shown in Figure 7 of the heating histories of similar sized stacks taken from actual operating data. It is to be noted that the temperature spread when heating through the laminations even after a "soak" of 16 hours is still 70 degrees while with the convector principle at 16½ hours, the spread is only 20 degrees. Both cycles produced physical characteristics entirely acceptable, one through a long time, low temperature process, and the other through a short time, high temperature process.

There are several points to be noted common in all three charges described. One, the furnace rates are in tons per stack hour and if expanded to 4-stack furnaces, the rates lie between 4 and 6 tons per hour for small and medium sized coils respectively. When coils of larger diameter are available, correspondingly larger tonnage rates are to be expected. Two, the tube temperatures were limited to 1550 F to protect the mild steel inner covers against excessive scaling. With the use of alloy or alloy clad inner covers, it would be possible to carry the tube temperatures at least 100 degrees higher, thereby further decreasing the furnace time.

While these points are of particular interest to the steel mill engineer, operator, and management because of the high production yields from smaller floor space and lower investment cost, a third point is of interest to the metallurgist. This is, that a small temperature spread is maintained throughout each stack over the entire heating cycle. This suggests the possibility of eliminating the so-called soaking period, because when a practical operating thermocouple reaches temperature, all parts of the coil are within an allowable range. It suggests the possibility of increasing the general temperature of the anneal without danger of grain growth in the outer wraps due to prolonged heating above the lower critical. In fact, a whole new field of metallurgical investigation is indicated in the uniformity of heat application by this process.

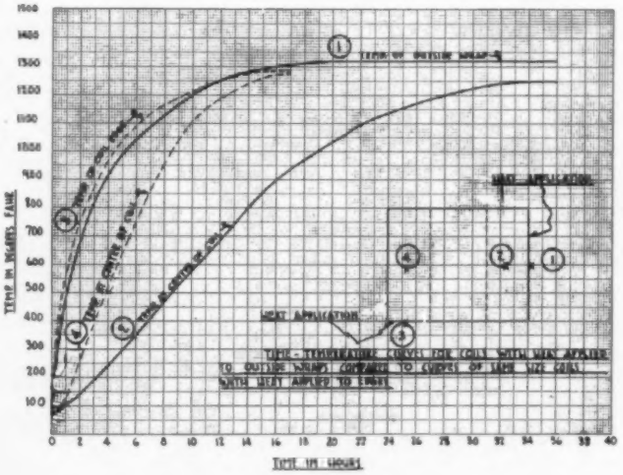
The economies of this annealing method will be of interest but before they are discussed, it should be pointed out that the figures given are on the basis of temperature uniformity which are far superior to those in general use today. On deep drawing sheet coils, with a temperature spread of only 35 degrees between the centers of all coils in the charge, the fuel economy is 1,100,000 Btu per ton.

Some increase in the use of power is required for operating the high capacity fans and while 15 hp motors are used to provide the power required during the very early portion of the cycle, and at the very end of the cycle when the gases are relatively cold, the average consumption is not over 7 hp. It is indicated that the cost of fuel, that is, gas plus electricity, will not exceed the present cost of the same fuels in existing furnaces for comparable temperature fields.

The real gain in this design is of course:

1. Tremendously increased uniformity of heat application.
2. More tons per hour in a reduced floor space.
3. A reduced first cost for a given tonnage to be annealed.
4. A reasonable processing time for large diameter coils.

Figure 7 — The distance between the dotted and solid curves for the two cases on this chart emphasize the advantages of edge heating.



DISCUSSION

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H. H. ARMSTRONG, Vice President in charge of Engineering, Lee Wilson Engineering Company, Cleveland, Ohio

J. W. Percy: Based upon annealing flat sheet by applying the heat along the edge of the sheet, it was quite obvious several years ago that the same principle should be used in the annealing of coil stock. As the authors stated, many experiments were carried out along these lines with somewhat indifferent success. The development of what they please to call a compensating convector is a step in the proper direction. I should be interested in learning the basis for its design in support of the authors' statement that its shape is such "as to deliver a uniform Btu release per square inch after the compensating effect mentioned above." It is stated that "as the gases move inward, the velocity is increased and the heat transfer rate maintained to the end of the path of the gases." To me, this conclusion is not obvious but open to some question.

Along this line of thinking, I wish to call the attention of the authors to the fact that a high velocity of gases is accompanied by a rapid heat transfer only within certain limits. Some experiments on this problem have been conducted, and it was readily determined that after the gas velocity reaches a fairly high value, the reverse becomes true and the rate of heat transfer actually decreases. It is possible that in the case of the compensating convector under discussion, the velocity of the gases and the heat transfer still maintain a positive relationship, but the question may bear investigation if it has not already been considered.

J. S. Stanier: While this paper is especially interesting to the people using the bell type furnace, it commands some attention from users of other furnaces.

We note from the figures given in the paper that tons per furnace increased from 0.4 per furnace hour to one ton per furnace hour, and then in the multiple stack, four to six tons per furnace hour. This calls for some attention when the figure attains four to six tons per furnace hour.

As a matter of comparison, we have drawn off approximately 400 tons of coiled material, in various widths, from 24 to 72 inches wide, annealed in a stationary in-and-out furnace, where some heat is radiated from the roof through the edges, and some heat from the bottom casting through the edges. On 400 tons, the rate per furnace hour is approximately 1.65 tons.

While furnace hour figures are of some importance on the efficiency of the operation, there are other features that should be connected with it in the way of fuel consumption, handling, and other incidentals in the furnace operation.

In comparison with the four to six tons per furnace hour, we wonder if there is any data available that might show the relationship between single stack and multiple stack annealing, and by that I mean the total consumption of fuel used in a four stack multiple furnace over the one-stack single furnace.

Another point that appears to be of interest is that in most of the illustrations a narrow width coil has been used. A good portion of the automobile extra deep drawing material in coil will range from 50 to 80 inches wide and some will be wider. There is no doubt that the separator is very important and increases the efficiency of the bell type annealing considerably. What would be the added efficiency if we were to anneal 60 and 72 wide coils, for example, in 120 inch and 144 inch bell type furnaces? You would have one separator, as compared with 24 inch wide coils, where you would have, I think, five separators.

W. H. Dailey: In general, the paper confirms the experimental work which has been done in our company over the past few years. We, however, still have the same question that has just been propounded, that is: "What is the effect of very wide coils, since the number of separators would then be reduced, and it would appear that the heat input surface would be reduced in proportion?"

The operating data that we have to date, however, although still experimental, does indicate that the paper in general is correct.

There are several rather serious problems that arise when considering the use of this type of equipment. Basically, they are due to the fact that you are annealing with horsepower instead of with Btus, as was the previous practice with ordinary equipment.

I am sorry that electrical people are not present to hear this paper and discussion, because of simultaneous sessions. To date, the proportion of investment cost in annealing equipment, going to electrical manufacturers, has been quite low, and now it looks as if they are going to get a large part of our investment in this equipment, too, and I think they need to do considerable development work on fan drives and fans, if the process does prove as successful as the paper indicates.

The experiments to date indicate that the rate of heating and cooling is almost in proportion to the horse-

power that can be delivered to the separators, and observation of the units that are running now indicates that a very small proportion of the input horsepower does any good due to low efficiency of drives and fan The circulating fans in previous designs were of relatively small capacity, seldom required more than one to two horsepower, and merely supplemented the radiation heat transfer so that the gas moving efficiency was not very important. Here is a case, however, where in a four-stack furnace you have over 60 horsepower. Certainly, if you could increase the energy delivered to the heat transfer surface from roughly 15 to 20 horsepower, as is the case now, to some 40 or 50 horsepower, which is certainly possible from the standpoint of fan design, we would get an even further increase in output over that shown by the author's performance curves.

H. V. Flagg: The development of the convector principle annealing furnace which has been so well described by Messrs. Armstrong and Schlitt has been quite interesting. There is little need for discussion of the principles involved since probably all of the manufacturers engaged in processing sheet steel in coils have long realized the advantages to be gained if, in the annealing process, heat could be applied to the ends of coils rather than through the sides.

One feature of the development which in my opinion has great significance is that forces of relatively great magnitude are being applied to a simple system in which it has been customary ever since the first cover annealing furnace was built, to depend on a four inch sand seal for control of the forces involved. The principle of convection heat transfer requires relatively high velocities, and in order that such velocities may be established and maintained, a relatively high suction must be developed at the entrance to the circulating fan which is just as effective on the seal around the drive shaft and on the bottom seal plate as it is on the gas passage back through the core of the coils. It is obvious that careful attention must be given to design and construction so that the bottom of the furnace can be made positively gas tight, and furthermore, so that it will remain gas tight with continued service. In view of this condition it would seem that, in discussion of the path of gases in this recirculating system, it would be pertinent to emphasize the minus pressure existing at the entrance to the fan rather than the static pressure at the fan discharge.

As the authors have pointed out, the convectors play a very important part in the performance of the furnace. The design of these convectors involves a very careful and detailed study of convected heat transfer, since gas volume and density as well as heat potential are constantly changing and compensating heating surface changes must be incorporated to equalize the heat transfer over ends of the coil from the outside lap to the center. Close temperature gradients within the body of the coil cannot be obtained unless this compensation is worked out properly. The Wilson organization is entitled to credit for their part in the development of this new system of heat transfer, involving as it does considerable courage, ingenuity, expense, and perseverance. Like all new developments, the embryonic phase involves many headaches which in due course can be worked out satisfactorily. I believe that this method of coil annealing can be worked out to the point where it can be a very practical and useful aid to the flat-rolled steel industry.

A. J. Fisher: Several years ago we attempted to use spacers between the coils being annealed in our cold strip annealing room. These spacers were heavy but not too carefully designed. When coils of smaller diameter were being annealed, the spacers overhung the circumference of the coil and drooped when heated. In addition, when the coils were not wound at the washers so that the ends were perfectly flat, or when the coils were telescoped, the load distribution across the face of the spacer was uneven. Where this occurred, the spacer tended to take the shape of the uneven or telescoped ends of the coil.

I would like Mr. Armstrong to discuss the problem of keeping the spacers flat when coils having varying diameters or slightly telescoped ends are being annealed.

J. Fallon: I have had experience in building 100 bell furnaces for various sheet and strip concerns in Great Britain. I was sorry that Mr. Armstrong did not mention, when he referred to the United States and Canada, that we have already three of these units under construction in Great Britain. We readily grasped the idea as having a sound physical advantage, turning the inner cover into a logical and scientific heat exchanger as against just the ashcan type.

The covers receive the heat from the tube and then compensate the convector to transfer the heat to the point where there is continuous conductivity to the rest of the coil. Also the more rapid removal by high convection of the heat received by the inner cover makes possible higher rates of delivery, hence the increase of radiant tubes from 80,000 Btu capacity up to 500,000 Btu capacity.

We in Britain feel, with considerable experience in direct firing, that to attempt uniformly high stacks, with gas under ration, to deliver heat as required to the surface of that inner cover would be asking for very very serious trouble indeed. It is only by disassociating the two functions of the furnace, by fully aerating the combustion gas in the inner tube from the direct approach of the convector, that we can reach these high thermal inputs. But I think with the factors presented to British manufacturers, it is evident that manufacturers are not concerned with the higher physics of heat penetration and so on.

I made a rough calculation on the two-ton stand, and found that in the complete heating and cooling cycles something like 60 tons of coil, with this circulation, for one short ton per furnace hour output. With a prolonged cycle you would need at least 120 tons at double capacities. Therefore, there was a saving of 60 tons.

I do not know and I do not care how much your strip may cost in America, but assuming $100 a ton, there is a saving right away in strip locked up in circulation of $6000 per ton of output per hour. When you think of that, plus the building and floor space, you find you can get one of these excellent units for nothing. That argument has gone over very well with the British. We are putting in three at present and hope to put in many more.

W. D. Lamont: The authors' company is going to make a trial run on some of this equipment in our plant

in Canada, so I came down to see whether I could get any other information than what they have told me. They are, of course, very enthusiastic about the whole thing. I agree with the last speaker that the thing in principle appears to be very worthwhile. Although the equipment is going to be run this week, we have no production figures as yet.

Victor Paschkis: The authors have contributed a very interesting solution to an old problem. The writer has dealt* with the principle underlying the problems of the present paper. Several questions come to mind in studying the present paper:

1. The authors mention a ratio between the thermal conductivity of solid steel and that of laminated steel, as 18-1 theoretically, and 8-1 practically. This is suprising in view of investigations made by the writer, and discussed in the paper by the writer and Finck quoted above. The writer found the ratio to be 44.5, and the actual experiment with wire coils published by Schack** yielded a value of approximately 40. It would be very interesting to have more information as to how the authors come to their values of 18 and 8 respectively.
2. Toward the end of the paper the authors mention that the tube temperatures were limited to 1550 F, and that by increasing the furnace temperature they would decrease the furnace time. They omit stating that this decrease of furnace time would definitely and unavoidably be accompanied by a poorer thermal uniformity.
3. The whole arrangement, as exemplified in Figures 2 and 4, has one difficulty which should be mentioned. The recirculating air, upon leaving the channel between the furnace wall and the inner cover, passes the outside layer of each coil. Part of the air is then sucked through the "compensating convector" to the center hole of each coil. Thus the outside and inside layer of each coil is heated excessively by hot gases passing over them. Additional heat is supplied through the compensating convector, but heating still occurs at least in part radially across the laminations. The authors have stated that this method of heating is undesirable. The highest degree of uniformity would be obtained by heating and cooling only from the ends and not at all radially. This would involve a fairly flat furnace not higher than one or at most two coils and heated only from bottom and top. Summarizing, it can be stated that the design shown in the paper is an improvement over the pure bell type furnace, but is not the best available solution for the heating problem. This statement is verified by the Figure 5 which shows a considerable temperature difference between centers and edge.
4. Temperature measurements, under conditions described by the authors, belong to the most difficult measurements to be made. It would be of interest if the authors in their closure would be more specific as to the technique of the measurements which they used.

H. H. Armstrong: The favorable reaction of those who discussed our paper was the same as that encountered throughout the strip industry whenever this method of heating was explained. It is to be expected that even greater economical advantages will be obtained when certain elements such as fan drives and fans can be developed specifically for this purpose.

The direct questions, while few, indicate that certain parts of the paper should be clarified as follows:

Mr. Percy requested that we explain more fully how the convectors compensate for the decreased temperatures of the gases as they pass from the outside of the convector to the inside. In detail, the gas passing through the convector loses temperature, and all other conditions being equal, the temperature gradient between the coil outer and inner edge would follow the pattern set by the gas temperature gradient. However, "all other conditions" need not be equal; that is, other factors affecting heat transfer can be altered to compensate for the loss in gas temperature. The other factors most influential are gas velocity and area of gas surface contact. By increasing the value of these two factors in the proper ratio to the loss in gas temperature, the net effect can be made an equal rate of heat transfer over every square unit of coil edge surface.

Regarding the velocity of the recirculated gas, it is well below any critical limit of which the authors are aware. Aside from design difficulties, even greater velocities would be desirable.

In answer to Mr. Stanier's question as to the fuel consumption for a single stack circular furnace as compared to that of a multiple stack furnace, there is some difference. This is due to the fact that the ratio of the outside wall area of a cylindrical furnace to the weight of the charge is much greater than the corresponding ratio for the multiple stack furnace.

The question was asked by both Mr. Stanier and Mr. Dailey as to whether this method of heating is as efficient for wide coils as for narrow coils. If all the coils to be considered were of the same thickness radially, the efficiency, or the ratio of heating times, would approximate the ratio of the number of convectors used per stack. For example, the heating time for a stack of four coils 30 in. wide in which four convectors are used, would be three-fourths that required for two coils 60 in. wide in which three convectors are used. In wide coils, two convectors should be placed between coil ends.

The following is to be said in answer to Mr. Fisher's request that the problem of keeping the convectors flat be discussed.

The problem of keeping the convectors flat properly begins with keeping the base charging plate flat. Unless this can be done, the convectors cannot be maintained in shape. Large differences between coil and convector diameters do cause excessive distortion of the convectors. When variations are small, the tendency to distort can be overcome by saw-cutting the outer edge of the convector to permit it to expand freely. The saw cuts must extend from the outer edge to a diameter approximately that of the smallest coil. The condition of telescoped coil ends has not been encountered except when it occurred during handling of coils, which of course flattened as soon as the coil was placed on a flat

**Temperature Uniformity in Heat Treatment of Coiled Metal* by Victor Paschkis and J. A. Doyle, Wire and Wire Products, May 1946; and *Thermal Properties of Laminated Materials and Their Significance for Uniform Heating* by Victor Paschkis and J. L. Finck, ASME paper delivered in Boston, September 30, 1946.

**A. Schack and E. Auhagen, Archiv f.d. Eisenhuettenwesen 4 (1930/31) p. 469.

convector. It has been observed that the edges are more uniform after heating than previously, which indicates that there is some slippage between adjacent wraps during heating when strain is relieved. It is conceivable that with the telescoping effect not too great, slippage would occur and eliminate the telescoping effect before the convectors came to such a temperature that they could be readily distorted by the coil end conditions provided that the surface of the charge plate remained flat.

Mr. Paschkis' questions are to be answered as follows:

1. If a coil of cold reduced steel is heated, the transfer of heat radially from wrap to wrap is by two means, conduction through the separating gas film, and from actual metal to metal contact. The effect of radiation is so small as to be negligible. Most coils are wound about 97 per cent solid, and if the gas film were of constant thickness, the resultant transfer coefficient would be 0.82 Btus per square foot per hour per degree F per foot thickness as an average from room temperature to 1200 F. When compared to the conductivity coefficient for solid steel, which averages 27 Btus per square foot per hour per degree F per foot thickness from room temperature to 1200 F the ratio is 32 to 1.

   However, this rate is slower than is accomplished in actual practice, so it must be assumed that contact points exist between wraps. Further, if it is assumed that the surfaces surrounding the contact points have the form of a surface of revolution of either a paraboloid or sine curve, the transfer rate is improved to 1.5 Btus per square foot per hour per degree F per foot thickness. This compared to solid steel at 27 Btus is a ratio of 18 to 1.

   The ratio of 8 to 1 is an average of many practical tests run in a rolling mill by its combustion department. The coils were stacked a minimum of two-high and a maximum of four-high, and no attempt was made to prevent heat entering the top and bottom coil ends. The quantity of heat thus supplied the coil ends had various effects on the apparent radial conductivity which was used in determining the 8 to 1 ratio.
2. Relative to Mr. Paschkis' second point, he apparently is not aware that in a tube fired annealing furnace, the tube temperature is controlled until a predetermined point in the charge reaches its final temperature, at which time the temperature control is shifted (usually automatically) to that point, and thus no part of the charge is allowed to overheat, and any degree of temperature uniformity required can be attained by sufficient length of time in the furnace.
3. Regarding Mr. Paschkis' third point, it can be stated that the outside wraps of the coils are subjected to the hot gases passing over them, but the velocity is low as compared with that passing through the convectors, and consequently the heat transfer is low in comparison. The heat thus applied to the coils is also compensated for by the design of the convectors, in that less heat is applied per unit area of coil end at the outer edge of the coil. The temperature of the gas flow in the core of the coil has been materially reduced and is not as effective in heating the coil radially as is the heat applied to the outside wraps. However, it is likewise compensated for by the convector.

   The authors have not stated that radial heating is not desirable, but only that it is much too slow due to the nature of the heat flow path. Further, any practical furnace equipment for strip coils would be unable to do selective heating; that is, heat would always be applied to all exposed surfaces by radiation or by natural convection.

   The temperature of the edge and center can be brought as close together as is necessary by additional time. The differences shown in Figure 5 are sufficiently close to provide satisfactory heat treatment for the majority of strip coils.
4. The temperature measurements were made by wrapping thermocouples into the coils during the formation of the coils. Several varieties of thermocouple wire were used, depending on what was standard with the mill in which the tests were run. All couples were iron constantan wire, some of which was round and some flat. The round wire was either glass fabric or refractory bead insulated; the flat wire was mica insulated. In all cases a great deal of care was exercised to avoid shorting of couples during placement and operation.

Plan to attend . . . .

ANNUAL CONVENTION

ASSOCIATION OF IRON AND STEEL ENGINEERS

WILLIAM PENN HOTEL

PITTSBURGH, PENNSYLVANIA

SEPTEMBER 22, 23, 24 AND 25, 1947

HEATING AND MELTING FURNACE CONTROLS

. . . . although it is not impossible to operate furnaces efficiently without instruments and control, such equipment, by eliminating the human element, invariably improves economy and quality . . . .

By C. G. BIGELOW, JR.
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▲ IN choosing instruments and controls for heating and melting furnaces, many factors merit consideration. From the furnace manufacturer's viewpoint, the emphasis too frequently has been on first cost when competitive price was the essential factor, while to the user first cost may not be as important, in light of probable advantages gained, maintenance required, and other considerations.

In fact, when confronted with the problem of what instruments cost, one belligerent reply was: "What difference does it make?" This approach, although startling on first thought, attains additional force when we see what large savings can be made in a year by the improvements possible with properly applied instruments and controls.

This "improvement by instruments" theme must be approached cautiously, even though most of us are thoroughly sold on instruments, as there are still some shops which say that high quality products are obtained at good fuel rate without benefit of instruments or controls; and their remarks are not without cause, even though they do use a few good temperature recorders where critical heating is to be done.

A good fuel rate without instruments and controls is not an impossibility. It is quite conceivable that a highly skilled heater or melter might run a well built furnace with good efficiency. Also, it is likely that an unskilled heater or melter would have a difficult time matching the results of his skilled colleague. Possibly the shops referred to above are dependent upon a few skilled "artists" and even though instruments and controls might not materially improve their work, they are extremely likely to improve the work of the unskilled operator.

However, the question of whether or not to include instruments and controls with a furnace need not lose itself in this one consideration; the choice of instruments by the customer and the sale of instruments by the furnace designer may hinge on an altogether different approach.

The problem of instrument and control selection divides itself readily into four main groups, which merit consideration by furnace designer and customer alike, viz., economic consideration, instrument and control selection, proper installation, and proper operation.

There is a certain overlapping of these factors in the following discussion which will be obvious from time to time.

The first item, that of "economic consideration," must include a critical analysis of all the economic factors involved in order to determine that the investment shows promise of good returns. These conditions must include on one side, a multitude of cost factors, among which are the cost of instruments, engineering, auxiliary apparatus, panels, installation labor, material, supervision, maintenance labor and spare parts. Also, some items of less importance include operation, collecting and interpreting records taken, teaching the operators, "down-time" due to instruments, metering loss and metering pipe, and possibly space occupied by the control equipment, which items are of little importance financially.

On the other side, we have the possible savings involved which will include fuel economy, improved product, increased product, increased furnace life, and supervisory control. These savings, though fewer in number are likely to reach considerably greater magnitude than the costs indicated above.

Now let us consider the elements under "economic consideration" one at a time to see to what they amount. It must be realized that all values given are estimates designed to give a reasonable idea of the magnitude of the cost involved and are not strictly applicable to any individual job.

In the temperature group, the cost of instruments themselves ranges from $5.00 to $10.00 for a simple low temperature indicator, to as high as $750.00 for a high grade temperature controller. Additions must be made

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to these prices for auxiliary equipment such as control valves, power units, panel boards, etc.

The pressure indication and control field covers a similar price range, as does also the flow indication and control field.

This is not such a coincidence as it would first seem because, in general, the recording and control equipment is similar if not identical, the only change being in the sensing element.

The price of ratio control will frequently be upwards of $1,000.00; gas mixing station equipment might run as high as $10,000.00; program control from $300.00 to $1200.00; gas analysis equipment from $500.00 to $2000.00; and Btu measuring equipment to about $6000.00.

In addition to the equipment costs itself, one must consider the instrumentation engineering costs of the builder or operator which vary considerably with the magnitude of the job. It would not be difficult, for example, to spend $40.00 to $50.00 to apply orifices and manometers to the fuel and air supply of a small furnace. This would involve choosing the range of the equipment, designing the orifice plates, planning the location, and placing an order.

The control engineering for a car-type furnace, comprising three zones of temperature control and three cross-connected governors, might cost $150.00 to $300.00, while the control engineering for a multiple zone continuous furnace with temperature control, ratio control, furnace pressure control, flow meters and panel, will cost about $1000.00. The instrumentation engineering for a two-hole soaking pit, completely instrumentized, will cost about the same.

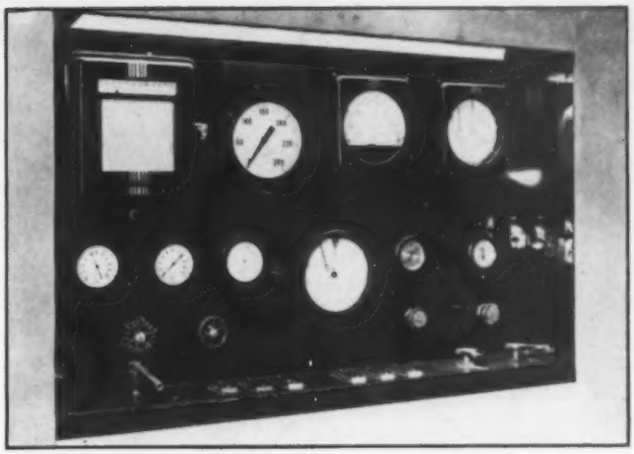
Under auxiliary apparatus, we find thermocouples from several dollars to about $100.00 depending upon material of couple, length, and protection. Control valves range from simple butterflies at $20.00 to complex, adjustable gate, plug valves in tandem at $600.00. Power units range from diaphragm air motors at $30.00 to powerful electric motors at $300.00.

Panels range from homemade supports at practically no cost to purchased panels amounting to $400.00. Ventilated glass and metal houses to enclose these panels amount to a great deal more.

Installation labor and supervision are estimated at from $50.00 or $65.00 per instrument, to as high as 25 or 35 per cent of the cost of the instrument plus auxiliaries, while the material for such installation might cost from $20.00 to $50.00.

Maintenance labor and spare parts present a difficult estimating problem. One shop has two instrument servicemen for three open hearths equipped with furnace pressure control, ratio control, checker temperature indicators, and flow meters, two large core ovens with temperature control, and twenty small car-type annealers with temperature control. This gives approximately two-man hours per day, per furnace installation, which means a constant charge of $2.00 to $5.00 per day, depending upon the complexity of the installation.

If this situation were handled by a service contract, the cost might run $100.00 per year plus the serviceman's expenses, and the cost of the new parts. The spare parts in both cases will probably run under 5 per cent of the initial investment, although some companies prefer to retain in stock at least one instrument of each type used.



The controls for a 35-ton open hearth furnace are mounted on this panel.

Now let us attempt to evaluate the economic advantages. It is difficult to guarantee benefits due to instruments and controls from a strictly operating standpoint because, as pointed out previously, it is conceivable that a good heater might operate his furnace at very high efficiency without instrumentation, and it is quite likely that, with proper pressure and flow indicators, he would do a very excellent job.

When a furnace shows high fuel rates, the furnace design and setting should be investigated as well as the need for instruments and automatic control. When fuel rates are really bad, chances are that about one-half the difficulty is due to operations which instruments and controls might correct. In no case, however, would a fuel saving much more than 15 per cent be expected, as beyond that point the question is, not how good the instruments are, but how bad the original operation was. In all cases we have the previous good records of the trade at which to aim.

Also, it cannot be said that the greater part of the advantage gained by instrumentation was due to any particular instrument such as furnace pressure control, fuel-air ratio control, reversal control, or temperature control, even though they might be preferred in that order on one application. Any of the above, if installed alone and first, would be expected to show a greater advantage than if installed second to, and in combination with, any of the others; however, the interrelating of two or more instruments into a control system may produce results which are materially better than the added values of individual controls.

Data are poor with regard to savings due to the addition of instruments and control, though the satisfied operators are many. Usually records are incomplete, and furnaces and operators have been changed during the period of comparison, but in most cases advantages are shown.

Let us see what fuel saving means with respect to an open hearth, a continuous furnace, or a small car-type furnace.

A 100-ton open hearth might have a fuel rate of 31 gallons of fuel per ton or burn about 340 gallons per hour over-all average. Ten per cent savings if accom-

plished or permitted by proper control of air and other features would amount to 34 gallons per hour at 5.2 cents per gallon, which is about $13,000 per year.

A car-type annealer on the other hand might process 50 tons in two days with an over-all fuel rate of 3,000,000 Btu per net ton. A 5 per cent fuel saving would amount to about $1.50 per day or $540.00 per year. Though the fuel saving in this type of furnace is not great, the saving in rejections might be considerable.

Examples on improved product are difficult to evaluate. The work that must be carefully heat treated is probably the most fertile field for examination, and those operators who were responsible for shell production during the war are known to appreciate results obtained.

Sometimes, reannealing runs as high as 20 per cent on car-type annealing jobs. This means that 20 per cent more fuel is required per ton of production, because temperatures were not properly controlled. Also, the overhead charges on the furnace are greatly increased by less satisfactory production.

The economic considerations of instruments and control merit a little summary of their own. Let us look at the following tabulation to see what we have found. Using pessimistic results for costs and conservative figures for savings we have on a 40-ton continuous furnace:

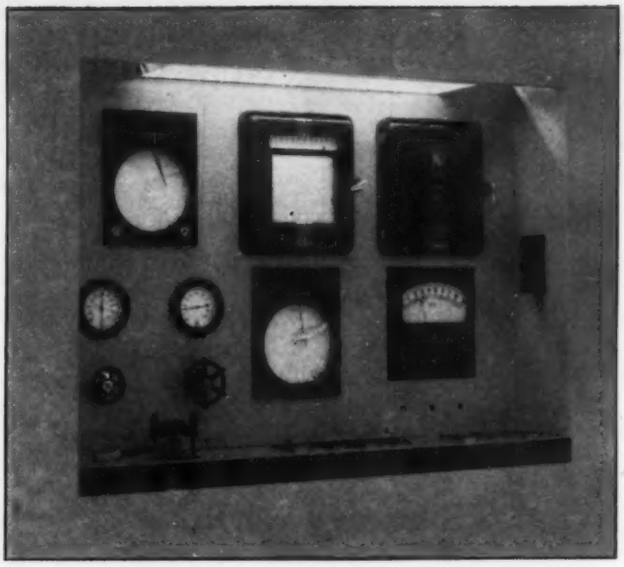
Savings per year:		
Fuel (5 per cent)	$8,600.00	
Improved product	1,000.00	
Increased product	1,000.00	
Increased furnace life	300.00	
Check on operator	10.00	
		$10,910.00
Operating costs per year:		
Maintenance	$ 100.00	
Operation	30.00	
Compiling data	360.00	
Instructing operators	50.00	
Down time	1.00	
Metering loss	65.00	
Space	60.00	
Financial charges (10 per cent)	480.00	
		$ 1,146.00
Net savings		$ 9,764.00
Investment:		
Instruments (one zone)	$3,000.00	
Engineering	300.00	
Auxiliary apparatus	600.00	
Panel	300.00	
Installation	600.00	
		$ 4,800.00

Time required for investment to pay for itself:

$$\frac{\text{Investment } 4800}{\text{Net savings per year } 9764} = \text{about } \tfrac{1}{2} \text{ year}$$

Now, in order that the advantages as illustrated above be attained, the instruments must be properly chosen, installed and operated as mentioned previously.

The second major consideration is the selection of the instruments themselves. This must include the primary choice of temperature, pressure, flow, ratio, or program instruments, etc.; the type of impulse transmission, whether electrical, pneumatic, hydraulic or mechanical, the degree of refinement necessary such as two-position, throttling, manual, or automatic reset, manual or automatic standardization, etc.; the type of instrument, whether indicating only, indicating and controlling, or indicating integrating controlling and recording; whether the proper safety devices are included; whether telemetering is desired; whether the equipment should be dust-proof, shock-proof, weather-proof, moisture-proof, heat resistant and, possibly, the make of equipment desired.



Good lighting aids in the accurate reading of the instruments on this control panel board for an open hearth furnace.

In furnace work the choice of primary equipment is not very difficult, temperature is very fundamental and at least a reliable indicator should be provided. The higher the temperature or the more exacting the finished product specifications, the greater our need for accurate and reliable temperature control.

Multiple zones may be necessary when the temperature desired in different parts of the furnace varies, as in a continuous or rotary furnace, or, when the exact temperature cycle progressed by all parts of the charge should coincide. However, if a more or less static condition obtains, at operating temperature, it is usually possible, with one zone of control, to adjust the burners so as to compensate for unequal heating losses, though variations in load from end to end of the furnace at every loading may make multiple zones desirable. One rule of thumb has it that zone length should never exceed three times firing width.

Furnace pressure control becomes more desirable the higher the temperature of the furnace, as the stack effect increases as the temperature increases with consequent increase in infiltration. Actually, the furnace pressure control usually functions to assure furnace pressure, since, without such control, and with sufficient stack and flues the furnaces usually operate with negative pressure and consequent loss of heating uniformity and fuel economy.

Annealing covers and box type annealers are examples of furnaces in the lower temperature ranges where temperature and furnace pressure control is applied to advantage. As these furnaces use protective atmosphere, this is a contributing factor to this choice as well as uniform temperature.

Flow meters are desirable as a check on controls and, in the integrating form, are frequently used to record and integrate fuel used in the furnace. On low temperature installations, indicating devices such as orifice plates and manometers usually suffice, while on higher temperature operations, recorders of the most expensive type available are usually applied.

Ratio control is more desirable as the temperature level rises, to save fuel and maintain quality, while at lower temperatures it is necessary to insure an atmosphere for the heating being done.

Annealing cycle programs are quite adaptable to program control, and are run accurately by relatively inexpensive additions to the main control scheme.

No particular advantage has been shown between electrical, pneumatic, or hydraulic control equipment. Some shops have preference which we respect. The mechanical types, if self acting, do not have the refinement of control gained with the others.

In fitting instruments to a simple application, such as temperature indication only, it is quite likely that a very simple type of equipment will do the job, and, in a similar vein, as the requirements as to accuracy and control increase, better and better equipment must be obtained. It will be found in most cases, that it pays to put the best equipment on your furnaces, as it can readily be seen from the previous examples that the price of equipment is small compared to the advantages to be gained. Why accept possible error in your temperature measurement, when temperature is such a fundamental part of efficient furnace operation.

Two or three-position devices will control, and possess the additional advantage of not being subject to load error, and consequently require no reset. A reset is necessary on all throttling types used for more accurate control when the load is not constant, and, it would be a very unusual process where the load was constant. Automatic reset we find to be quite an advantage where the load error varies greatly, as when great demands are made upon a furnace such as a batch furnace where the size and temperature of the billets being charged are constantly changing. Furnaces of more or less stable operation can be operated nicely without automatic reset, but furnaces which have different loadings or temperatures at each cycle make automatic reset a distinct advantage. The possibility of different requirements in the future may make it desirable to include more flexible control than immediately necessary.

When orifice meters are involved for control schemes such as fuel-air ratio, changes in temperature of gases being measured affect the accuracy quite noticeably. The era of making temperature correction a day later is fast disappearing, as accurate control requires the correction to be made instantaneously.

Instrument cases are usually designed so that any one or any combination may be obtained from indicating only, to indicating, integrating, recording and controlling. For certain operations requiring only indicators, recorders are sometimes specified. As a result, the data are not collected, the recorder chart not changed, the instrument falls into disrepair, and the effort to obtain proper indication is lost. Most of us choose recorders on controllers so that some record of the performance of the controller is given. However, once we are satisfied that the controller is capable of doing the job well, we might find it possible to substitute a non-recording controller.

In cases where total amount of fuel burned is desired, the integrating recorder is quite useful, as it saves the labor of integrating the chart after the run is complete.

Most control manufacturers realize that their equipment should operate safely and fail safely, and, when choosing equipment, safety is one thing of which we should be certain. Safety shut-off valves in many cases can be included to shut off the fuel in case of any fault in any of the control equipment, or power failure.

Practically every type of measuring device is capable of being arranged for remote reading, so that either the operator or the central office may have the necessary records at the most accessible location.

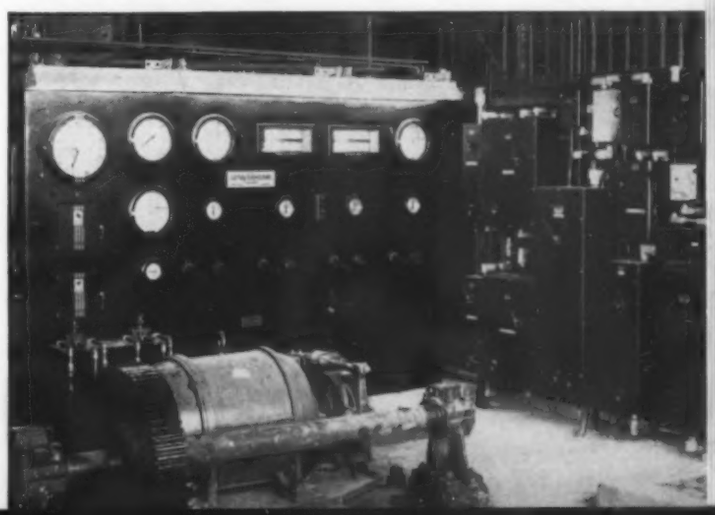
A telemetering arrangement was used by one heat treating company so that the operator would have an indicator, and the central office a record of what each furnace did. The records showed up beautifully, but the product was quite bad and it became necessary for the management to put an investigator in the department to see what the difficulty was. He noticed that as the heater went up and down the line, unusual adjustments were made at the thermocouple of each furnace, and finally it became quite obvious that the thermocouples were being moved to a point where the ability to measure correctly was greatly impaired.

Upon being questioned by the investigator, the operator stated that he had been instructed to keep the pointer at a predetermined figure and that by "pulling this thing on the side of the furnace in and out," he was able to do that. Needless to say, his method of controlling furnace temperature was not approved by the management and illustrates the desirability of basic education in the principles and purposes of instrumentation.

The ability of the equipment to withstand mill vibration and shock is important, and protection from dust and moisture greatly lengthens its life.

The equipment make preferred by the customer is

This panel provides the nerve center for a continuous billet heating furnace.



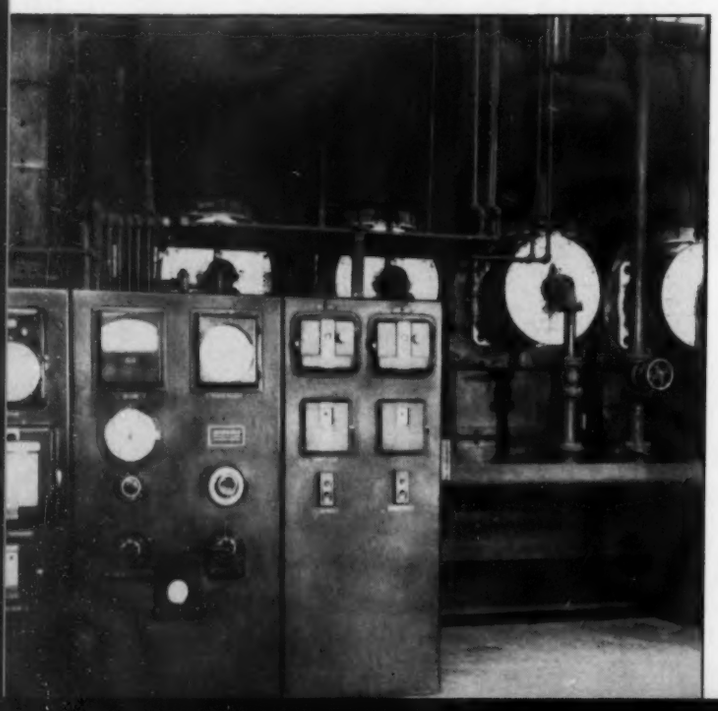
usually our guiding light as a furnace builder; that is, if the customer has standardized on a particular make or type of equipment, we use the product which is familiar to him. However, occasionally, it might be wise to deviate from his standardization in make or type of instrument in order to secure the best performance from the furnace design or to make use of the latest improvements in instrument design.

The elements for consideration in the case of proper installation are: the best practical location of the sensing element, a suitable location of the control element, a satisfactory operation of the control element, proper electrical supply and protection, proper air supply, clean hydraulic oil and pipes, unobstructed impulse lines, pulsation dampening, if desirable, and, above all, proper following of the basic installation diagram.

We all know that it is a fundamental truth of control that the factor to be controlled must be measurable, and to measure it we must have the proper measuring device at a point where it will make this measurement. This is true of indicators or recorders, but becomes increasingly important where automatic control is involved. If the sensing element is not located at a point which represents the conditions we wish to measure (which to be practical should be the final condition of the product), we cannot expect usable results.

One company had installed a new car-type furnace with several temperature control zones. The furnace was unique, in that it had the back wall mounted on the car so that the furnace could be shortened to the minimum required for the load being processed. Invariably, the back of the load became over-heated. It was only with the keenest observation that the difficulty was noticed and corrected. It seems that the designers were farsighted enough to cut a slot in this movable back wall so as to clear the thermocouples when the car was withdrawn. Unfortunately, however, the slot frequently came close enough to the thermocouple to prevent furnace radiation to a large part of it. Consequently, the thermocouple had to be lowered below the level of the slot in the back wall before proper response was obtained.

End view of an in-and-out slab heating furnace with controls.



The straight pipe needed for an orifice run is an old headache to most instrument men, although most of them have tried at some time to see how short this section really could be. Someday we all hope to have suitable, inexpensive metering equipment which will make long straight runs unnecessary, but until that equipment is found, we will do well to take advantage of the recommendations made by those who have had opportunity to study the problem to help us obtain reliable metering.

The location of furnace pressure elements is sometimes a problem, and we have found examples of a wide range of furnace pressure tap locations. However, if a controlled pressure is to be maintained at the hearth level over any appreciable temperature range, then the pressure compensating should be taken at hearth level so as to avoid the change in pressures of different elevations due to stack effects in the furnace. Also, the proper atmospheric compensating line should be brought to the controller with the furnace pressure impulse line.

As it is necessary to carefully locate the sensing element and the controlling element, it is also necessary to locate the controller properly. The panels or instruments should be so located to be visible and accessible, but physically protected from damage from heat, vibration, etc.

Frequently the controllers operate equipment such as stack damper, butterfly valves or fuel valves, and, in order to obtain good operation, this equipment must be carefully designed so as to operate as smoothly as possible and be operable with the power available. Sometimes it is necessary to clean butterfly valves or check the counterweight balance on the stack damper. Lost motion in linkage is very undesirable.

In some steel plants it has been found that the electrical supply voltage occasionally drops to a point where electric relays become insensitive, or cease to function altogether. Obviously, good control cannot be obtained under such circumstances. Also if the circuit is not protected for such light duty equipment as instruments, a separate protection should be installed, so that failures occurring in the instruments will cause the fuse to blow before any expensive instrument or motor is burned out.

It is very essential that control equipment have a supply of clean compressed air at a regulated pressure, so that it may do its job well. Oil getting into the air at the compressor frequently causes difficulties in the control equipment.

Strainers must be installed carefully in pneumatic or hydraulic systems so that orifices in the control equipment do not become plugged, or valves and pistons scored.

One difficulty which is frequently encountered is that water condenses in pockets in the impulse lines, and the impulses are no longer transmitted to the equipment. Pockets should be eliminated; drip legs should be used, and all lines sloped toward them.

If the impulse being measured fluctuates rapidly, and

this fluctuation is not important to the record or the control, it is usually desirable to throttle this impulse, so that these rapid minor variations have little or no effect and moving parts are not unnecessarily worn. Caution must be used as throttling flow impulses tend to give erroneous reading.

Obviously it is essential that the manufacturer's basic installation diagrams be followed completely during installation.

Proper operation cannot be expected if installation is improperly made, or if maintenance is insufficient. As many difficulties are caused by tampering, the vigilance of the maintenance man must never cease. The instruments must be kept clean and lubricated, charts changed, the batteries renewed, the standard cell protected, thermocouples inspected and changed, orifice plates and manometers cleaned, and calibration checked.

In discussing these factors for consideration in choice of instruments, these conclusions are drawn:

The final choice to add instruments and controls to a given furnace must be decided by relating furnace performance to performance of similar furnaces throughout the industry; that is, we should not expect to improve a fuel rate if it is already comparable to the best. We should not expect to improve the temperature control of a heat treating furnace if no rejections are being obtained. We should not expect to improve the operation of furnace pressure equipment if the stack and flues are insufficient.

All of this adds up to the conclusion that if the engineering department chooses the equipment well, the builder installs it carefully, and the maintenance men and operators use it wisely, the possible benefits will surely be proved to the owner, in efficiency of operation as well as quality and economy of product.

DISCUSSION

PRESENTED BY

JOHN R. GREEN, Manager, Steel and Ceramic Division, The Brown Instrument Company, Philadelphia, Pennsylvania

JOHN A. DUFAULT, Sales Engineer, Leeds and Northrup Company, Cleveland, Ohio

C. G. BIGELOW, JR., Assistant Chief Engineer, Furnace Division, Loftus Engineering Corporation, Pittsburgh, Pennsylvania

John R. Green: In connection with the amount and extent of instrument usage, it should be recognized from the angles of both product quality and fuel economy, that improvements in furnace design frequently make better instrumentation and control possible. Therefore, a major part of the improvement is not realized if adequate control is not incorporated.

In regard to the comments on instrument selection there is an additional basic function which the builder can and should perform for the customer. The customer's primary requirements, such as uniformity of temperature, effects of furnace atmospheres, importance of fuel economy or furnace life must be carefully reviewed in the light of a particular furnace design to determine the variables which are most desirable to control or are controllable.

For example, the actual product temperature may be measured in a batch type heating furnace, such as an annealing cover, permitting regulation of fuel input from that reading by any number of methods depending upon furnace design; while a continuous furnace may permit only the measurement of a temperature which is related to the final product, such as furnace temperature, which in turn permits regulation of either fuel input or speed of travel through the furnace to produce the desired result.

The individual furnace manufacturer or designer is in the best position to perform this fundamental selection of method which shall be used in measurement or control if he is given complete information on the customer's requirements and objectives.

With reference to the practical aspects of keeping control equipment in operation, the maintenance departments of mills have many problems to solve. To have a good instrument department, the men must work on electric, hydraulic, pneumatic, or mechanical equipment. With the increase in refinements of control and complexities of the processes, it becomes impractical to divide instrument maintenance responsibility on a furnace or process between electricians, pipefitters, fuel or metallurgical departments, since a variety of control types and methods may be used to accomplish the best operating results.

John A. Dufault: First of all, management is now pushing for more production and lower costs. Automatic controls of all kinds help in that direction. It will help you to improve the quality of your product by maintaining your temperatures or your pressures or whatever quantities you measure very constant. They will help to prolong furnace life, because if you hold the process constant the furnace itself lasts longer.

When you carefully consider the results to be obtained from these automatic controls as against the cost of the entire equipment, you find that it does not take very much saving to justify controls such as temperature control, that may cost you about two dollars a week. I think the higher fuel cost and push for improved product at lower cost well justifies your very careful study of all automatic controls.

C. G. Bigelow, Jr.: Mr. Green suggested that the furnace builders could do a better job if the customer's primary requirements were known. That covers much ground. Even when the customer's requirements are known, or are given, he frequently has a very farsighted opinion of how many tons of steel he is going to make ten years from now, and asks us to design equipment with capacity which frequently is as much as ten times the amount that he actually uses. Obviously, the control equipment cannot be very sensitive when a furnace designed for fifty tons runs at five. So perhaps we should insert the "customer's actual requirements" there, along with his primary requirements, in order for us to do the best job possible.

Mr. Dufault pointed out that we are pushed by management more and more for greater production and greater savings, and it was with that in mind that I prepared this more or less mental gyration of a control engineer, so that it might perhaps encourage control men to dig up cost and saving factors so that when management says "You don't want to do that," or "You don't need to do this," there may be "ammunition" available to support the argument for automatic controls.

Speed Stability . . . .

OF MOTORS FOR CONTINUOUS MILLS

. . . . the only way to minimize speed change when sudden torque variations occur is to supply sufficient counter torque . . . . this may be done mechanically by providing inertia or electrically by proper design of the electrical characteristics of the motor . . . .

By F. E. CREVER and T. M. LINVILLE
GENERAL ELECTRIC COMPANY
Schenectady, New York

▲ TANDEM mills for rolling steel play an increasingly important part in meeting modern high production requirements for steel products. These mills consist of several sets of rolls or stands arranged in line so that the metal may pass from stand to stand in one continuous piece, and leave the mill in its finished form. Ordinarily the metal is of sufficient length to extend through several stands and in many cases it extends throughout the entire mill.

It is, therefore, necessary that the speeds of the various stands be co-ordinated so as to pass the same amount of metal through all stands in a given interval of time. As the area of the metal is reduced in rolling, the speed of each successive stand is increased so that the entry speed of any stand will equal the delivery speed of the preceding stand. For a given gauge and product, the speed relationship between stands should be established and maintained accurately because there would otherwise be a tendency to excessively stretch or loop the metal between stands. In some mills the metal is purposely stretched between stands, to aid the rolling process, while in others it is desired that there should be neither stretching nor excessive looping. While tandem mills are best suited to high production of large orders, it is necessary for a given mill to be sufficiently flexible so that various products of a similar nature may be rolled. Therefore, it is a requirement that the relative speeds of the various stands be readily adjustable. For this reason, and also because their use simplifies the mechanical layout of a mill, it is common practice to drive each stand by a direct-current motor. Power is furnished to the motors by one or more d-c generators. Often one common d-c bus furnishes power to all motors of the mill, but in some instances the generators are electrically separate and are arranged to supply various groups of motors to best suit the requirements. When separate generators are used, their voltages are co-ordinated by the control system. The relative speeds of the various stands are adjustable by motor field control of the various motors, and the whole mill is raised or lowered in speed as a unit by varying the generator voltage.

If the material being rolled were infinitely continuous, the relative speeds of the several driving motors could be adjusted once and then be maintained in this relationship with relative ease. Such is not the case as the metal is put through the mill in separate bars following each other in succession separated by intervals when no metal is in the rolls. Thus the motor loads change frequently and abruptly from friction load to rolling load. As the front end of the metal hits each stand, there is an impact speed drop due to the sudden load application which is applied to each stand in succession as the front of the metal travels through the mill. This tends to upset the proper speed relationship between stands at least momentarily, and may cause excessive stretching or looping of the metal between stands. It is therefore of importance to consider the characteristics of d-c motors under these conditions. Also it is important to consider the requirements of the various types of mills so that the most suitable motor characteristics may be designed to suit the particular application.

CHARACTERISTICS OF D-C MOTORS WITH SUDDENLY IMPRESSED LOADS

A d-c motor operating with given field flux develops a torque that is directly proportional to its armature current. It also develops a counter emf that is directly proportional to its speed. Figure 1 has been prepared to

Presented before AISE Annual Spring Conference, Chicago, Illinois, May 7, 1946.

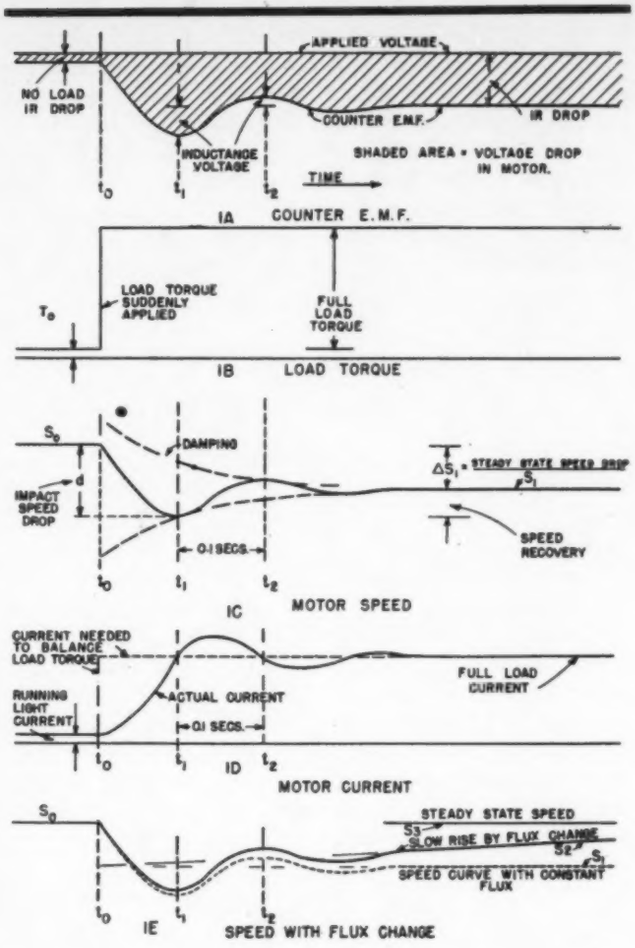


Figure 1 — When a load is suddenly applied to a d-c mill motor, an appreciable time elapses before a steady state condition is attained.

illustrate what happens with such a motor when load is suddenly applied. Consider the motor to have constant voltage applied at all times as shown in Figure 1A. Let the motor be running without load developing a small torque, T_o, just sufficient to overcome the no-load losses.

Now let full load be suddenly applied as shown in Figure 1B. The motor will start to slow down as shown in Figure 1C with the rate of deceleration depending at the start on the moment of inertia of the rotating parts. The counter emf in Figure 1A is decreased, causing the voltage difference between counter emf and applied voltage to increase. In response to the increased voltage difference, the motor current increases as shown in Figure 1D, causing the motor torque to increase.

At the instant t_1 when full load current is reached, the impact speed drop is at its full value d, Figure 1C. At this instant the voltage drop in the motor is not IR drop alone but inductance drop in addition as shown in Figure 1A. Therefore, the voltage drop (which is always equal to the difference between counter emf and the applied voltage) is more than sufficient to overcome the IR drop of full load current. Consequently, the motor current and torque continue to increase causing the motor speed to increase. This increases the counter emf reducing the difference between applied voltage and counter emf. Thereby, the increase of current is gradually stopped and then the current is caused to decrease. At the instant, t_2, when the current is once more equal to full load current the rise of speed has reached its full limit. At this instant the voltage drop in the motor is equal to full load IR drop minus the inductance drop. The voltage difference between counter emf and applied voltage now is insufficient to overcome the IR drop of full load current. Consequently the motor current and torque continue to decrease, causing the motor to lose speed again and start to repeat the cycle. The train of speed swings, starting in this manner, are very quickly damped out and the speed settles down to the steady state speed S_1, Figure 1C. This is the speed at which the voltage difference between applied voltage and counter emf exactly equals the full load IR drop of the motor. The speed drop ΔS_1 in per cent of the no-load speed is equal to the IR drop in per cent of the applied voltage.

In most motors the flux or the applied voltage are not constant because means are provided to obtain a steady state speed drop of a desired amount not obtainable without changing the applied voltage or the motor flux. This does not affect the speed curve, Figure 1C, other than to tilt the curve slightly upwards to reach the desired steady state speed S_3, shown in Figure 1E. In Figure 1E the motor speed does not follow the dotted line (which is the same as in Figure 1C) but follows the solid line which is slightly higher. The impact speed swings occur just the same but about a sloping axis S_2 instead of the axis S_1. Hence impact speed drop is a characteristic quite separate from the steady state speed drop.

The impact speed drop may be defined as the magnitude of the first speed swing below the initial speed as a result of instantaneous application of full load torque.

The steady state speed drop is the magnitude of the final speed change from the initial speed after the speed has reached a steady value, as a result of full load torque application.

The fact that a motor has good steady state speed regulation is no guarantee that it will have low impact speed drop. This is to be emphasized because many of the means effective in obtaining good steady state speed regulations have little or no effect on the impact speed drop. This is true of the ordinary means of obtaining motor flux change by control methods such as series exciters in the motor field, and is also true of the effects of armature reaction if present because they are too slow to affect the impact speed drop other than as shown in Figure 1E.

It is possible with any given motor to obtain impact speed drop without speed recovery, that is, to have the speed change smoothly from S_0 to S_1 without the swings of speed shown in Figure 1C. This can be done by either adding inertia, as by a flywheel, or by increasing the resistance of the motor armature circuit, or by decreasing the inductance of the circuit. This is illustrated by the curves of Figure 2. The amounts of inertia, resistance, or inductance which will just give impact speed drop without speed recovery are called the "critical" amounts. The performance of the normal motor is illustrated by curve C. In order to have small impact speed drop the resistance should be low, and, therefore, it is not practical to add resistance. Comparison of curves B and D shows the increased impact speed

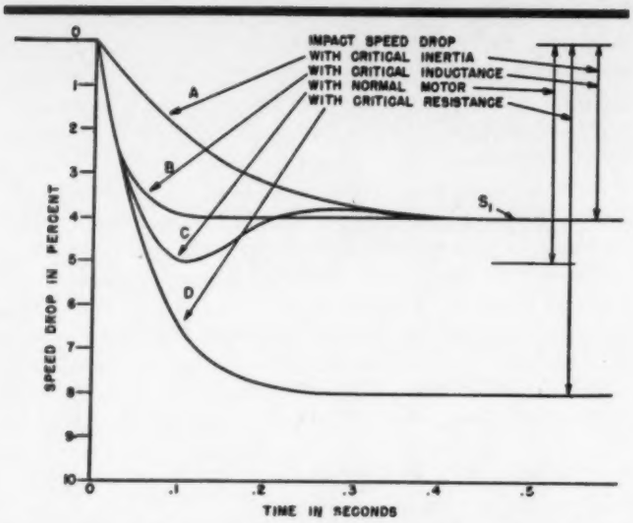


Figure 2 — By proper design, it is possible to get impact speed drop without speed recovery and resultant speed fluctuation.

drop when resistance is added. A flywheel can be added to give curve A when the application justifies its use. When the wheel is of sufficient size the deceleration of the motor will be slowed enough to make the inductance drop in the motor zero at the instant when the current reaches full load current. Then the difference between the applied voltage and counter emf is just sufficient to overcome the IR drop of full load current. Therefore, in this case, the motor current has reached its limit and the motor speed will settle down immediately to the speed S_1. The amount of flywheel that is necessary depends upon two time constants of the machine as will be shown later on. Similar results except with faster speed drop are obtained by decreasing the inductance of the motor, curve B. One way to summarize these results is to say that, in general, the lower the resistance of the motor armature circuit and the higher the circuit inductance, the greater will be the moment of inertia necessary to obtain impact speed drop without recovery.

When motors are running with weakened field to obtain higher speeds with the same applied voltage, the current required to overcome a given load torque is greater. Therefore, the counter electromotive force change must be greater to circulate enough current to overcome a given load torque. Also it requires more speed change to cause a given counter electromotive force change. A given amount of inertia gives up more energy as a result. Therefore, the size of flywheel to be added to obtain impact speed drop without recovery is a maximum for the base speed of the motor. Complete information is given later in the paper about the critical values of inertia, resistance, and inductance needed to obtain impact speed drop without recovery at any operating speed.

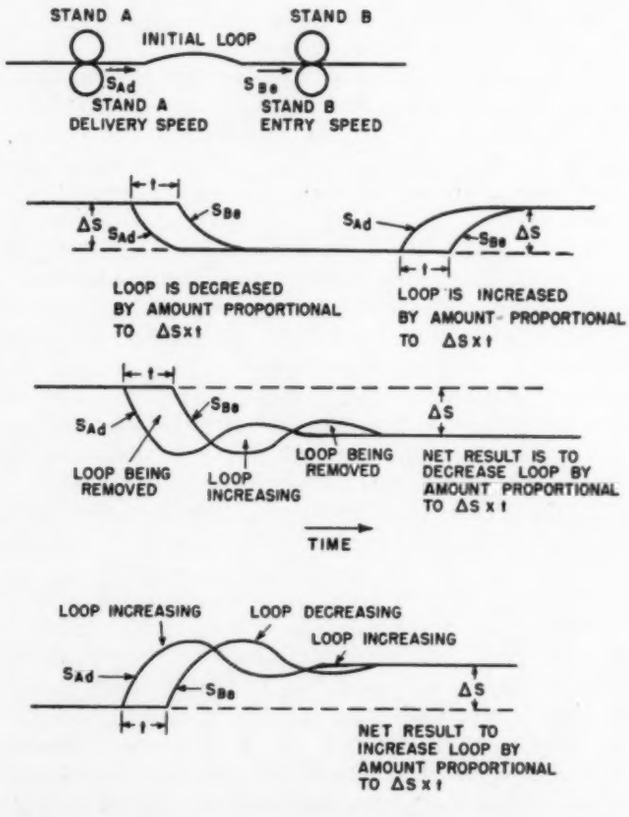
The foregoing explanation of what happens when a d-c motor is suddenly loaded applies equally well when load is suddenly removed. In the latter case the curves of Figures 1 and 2 are inverted, becoming sudden increases in speed instead of speed drops.

In presenting an analysis of impact speed drop the load is assumed to be applied abruptly as shown in Figure 1B. This is done to make the analysis simpler, easier to understand, and because the results are the same when other abrupt changes in load are assumed and superposed upon one another. The analysis leads to means for stabilizing the impact speed characteristics of motors as well as the steady-state speed characteristics. In general, motors of close speed regulation under both impact and gradual changes of load are desirable where looping of the material being rolled is undesirable.

EFFECTS OF SPEED CHANGES ON MATERIAL BEING ROLLED

Consider the speeds of two stands, A and B, as illustrated in Figure 3 in terms of the delivery speed of stand A and the entry speed of stand B. Let there be material continuously in the stands and let there be at all times a loop between stands. If now the speed of stand A is decreased in some manner by an amount, ΔS, and at a time "t" later, the speed of stand B is decreased in the same amount and at the same rate as stand A speed was decreased, the net effect of the drop in speed is to decrease the initial loop by an amount proportional to the product of ΔS and t. This is true regardless of the shape of the speed time curve followed during the speed decrease as long as both stand speeds follow the same shape displaced in time by the interval t.

Figure 3 — Effect of speed changes in the delivery and entry stands, when an initial loop is present, and when the speed changes at each stand are separated by a time interval.


STAND A
STAND B
INITIAL LOOP
S_{Ad}
S_{Be}
STAND A DELIVERY SPEED
STAND B ENTRY SPEED
t
ΔS
LOOP IS DECREASED BY AMOUNT PROPORTIONAL TO $\Delta S \times t$
LOOP IS INCREASED BY AMOUNT PROPORTIONAL TO $\Delta S \times t$
LOOP BEING REMOVED
LOOP INCREASING
LOOP BEING REMOVED
NET RESULT IS TO DECREASE LOOP BY AMOUNT PROPORTIONAL TO $\Delta S \times t$
TIME
LOOP INCREASING
LOOP DECREASING
LOOP INCREASING
NET RESULT TO INCREASE LOOP BY AMOUNT PROPORTIONAL TO $\Delta S \times t$

If the speeds are increased in a similar manner, the net result is an increase in the loop proportional to the product of ΔS and t. This holds true even though there is overshoot and then recovery to the final value so long as there is always a loop in existence during the action. Under these conditions, characteristics that give good steady state speed regulation either inherent in the motor design or in the control system will be effective in controlling the loop.

If the material is tight between stands originally as in Figure 4 and a speed decrease takes place first on stand A and later on stand B, the initial stretching disappears. There will be no looping unless there is a momentary speed increase. If there is even a momentary speed increase, there will be looping. This cannot be controlled by any means which does not affect the impact speed characteristics. It is not sufficient to merely obtain good steady state speed regulation, as this can only give recovery from the original impact speed drop with consequent looping proportional to the recovery. The best means of controlling this effect is by means of motors with inherently good impact speed drop characteristics.

With these principles in mind we shall next examine the various types of continuous mills to see where the effects just described are of importance.

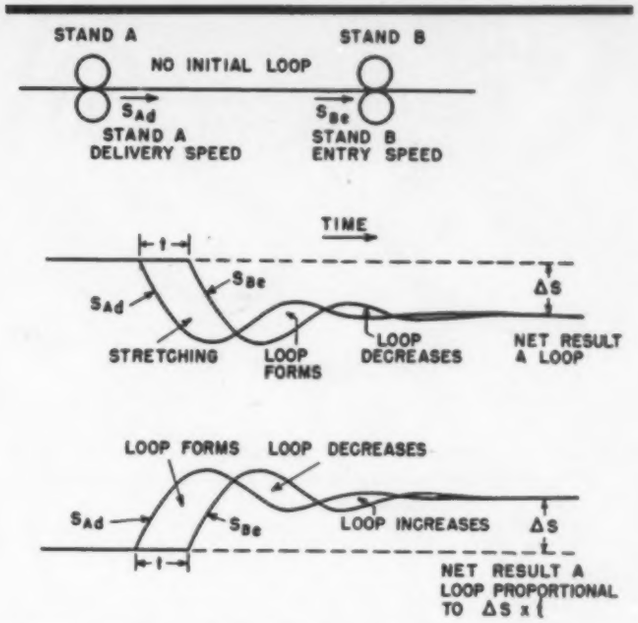


Figure 4 — Effect of speed changes in the delivery and entry stands, when no initial loop is present, and when the speed changes at each stand are separated by a time interval.

CHARACTERISTICS REQUIRED OF DRIVES FOR VARIOUS TANDEM MILLS

Cold strip mills — The material supplied to a cold strip mill is a relatively long coil which is threaded through the mill at low speed. The whole mill is then rapidly accelerated and run at high speed until the coil is nearly used up and then the mill is decelerated to thread speed while the tail end of the coil is rolled. This process is repeated for each coil and hence acceleration requirements are much more important than impact speed drop characteristics. When the coil is being threaded through the mill, the front end is entered into the various stands by the operator, and a loop forms between stands before the front end enters the next stand. The impact speed drop that occurs causes a loop that does no harm because there is already a loop behind the stand. The action is illustrated in Figure 5. Stand A speed transient is damped out and stand A delivery speed has reached the steady state when the strip is entered into stand B. Loop removal begins at once and continues until stand B entry speed has dropped to equal stand A delivery speed. This is ordinarily insufficient to remove the original loop but even if it were, the loop would reform as stand B drops further in speed. Subsequent recovery of stand B speed causes loop removal, both because stand B speed overshoots the steady state value without tension and because the steady state entry speed of stand B without tension is greater than the steady state delivery speed of stand A without tension. The effect of impact speed drop alone cannot remove the loop because each successive speed swing is so highly damped that the looping due to the first swing of S_{Be} below S_{Ad} is greater than any subsequent loop removal due to impact speed swings. Therefore, the speed settings should be such that the steady state value of S_{Be} is slightly greater than the steady state value of S_{Ad} before tension is established. This will cause the loop to be removed at a gradual rate so as to establish tension without a violent snap which might break the strip.

From the above it can be seen that impact speed drop is not an important factor on cold strip mills.

The steady state speed characteristics are of importance. Good steady state speed regulation gives desirable operating characteristics because small fluctuations in load on each mill motor due to variations in width, thickness, and hardness of the strip do not cause marked motor speed changes. As a consequence it has been observed that with good steady state speed regulation, the gauge indicating instrument is more steady and stays nearer the "on gauge point" than with excessive steady state speed regulation.

Motors for cold strip mills are designed primarily for low inertia to meet the important acceleration requirements. Provision is also made to obtain close steady state speed regulation either inherently or by means of the control system.

Hot strip mill — In a hot strip mill the slabs are put through with the various stands running at full speed. One slab follows another separated by an interval when no steel is in the mill. Thus each stand sustains an impact speed drop as the steel enters and the impact speed drops of successive stands are displaced in time by the time required for the steel to travel between stands. This is illustrated in Figure 6. The operator usually adjusts the speed to get $S_{Ad} = S_{Be}$ under the load condition. The no-load speeds are not necessarily equal unless both motors are alike in characteristics and both are proportionally loaded. This is not important as no steel is in the mill under this condition. As soon as the steel is in both stands, stretching occurs as shown until S_{Be} drops below S_{Ad}. On a hot strip mill, moderate stretching does little harm. Subsequently

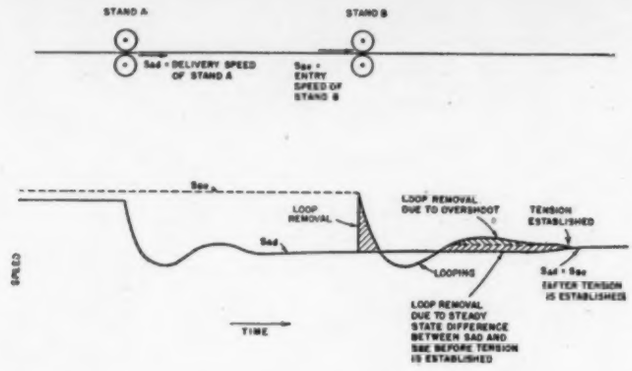


Figure 5 — Impact speed drop is not an important factor on cold strip mills, but the steady state speed characteristics are important.

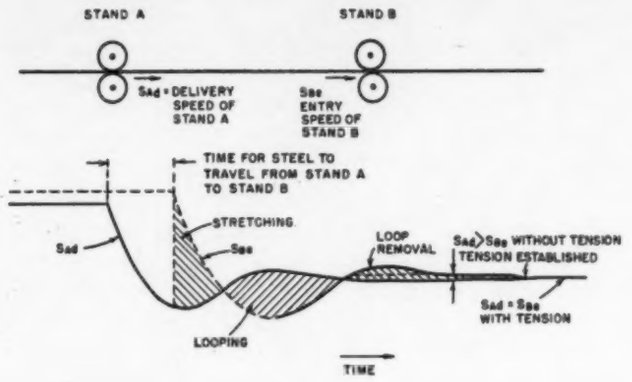


Figure 6 — Impact speed drop is an important factor in the design of a hot strip mill.

there is a loop thrown as shown and while this loop may be partially removed, the net effect of the impact speed drops is to throw a slight loop. This does no harm unless it is so excessive as to cause the steel to fold over and enter the next stand in this state. Usually hot strip is now rolled with a small amount of tension between stands and the motors have moderate steady state speed drops. If S_{Be} steady state value before tension is established is slightly higher than S_{Ad} steady state before tension establishment, the loop thrown as a result of the impact speed drops comes out automatically after which the establishment of tension causes the speeds to come together as shown in Figure 6. A normal amount of motor speed regulation makes the tension adjustment less critical than would be the case with a flat speed characteristic. This is true because when there is some speed regulation, the motor speeds adjust themselves to accommodate the establishment of tension, whereas with a flat speed characteristic the tension would depend upon the settings being made in just the right amount to accommodate the stretch of the material at the desired tension.

Motors of normal design give very satisfactory operation for this service.

SINGLE STRAND BAR AND MERCHANT MILL

One stand per motor — These mills are running at full speed when the material enters, and hence consideration must be given to the impact speed drop characteristics due to sudden full load application. The mills vary greatly in their layout and consideration must be given to the product as well as the mill layout in determining the requirements of the motors. In general slight stretching is not serious and looping may or may not be detrimental depending upon the mill layout and the product to be rolled. Wherever the mill is run with loops between stands, impact speed drop has little effect and hence standard motors are suitable. On closely coupled stands and on some products such as angles or other light sections, looping cannot be tolerated, particularly in the finishing end of the mill. In such instances, high inertia motors having low resistance and inductance are necessary. Flywheels are not usually necessary because at the higher speeds obtained by motor field weakening, the inertia of a high WK^2 motor is sufficient to give impact speed drop without recovery so as to prevent looping. If, however, products that cannot stand slight looping are to be rolled at base speed, flywheels may be considered.

The action is very much the same as shown in Figure 6 for the hot strip mill. As in the hot strip mill, a moderate amount of steady state speed regulation is desirable because it makes tension adjustment less critical as previously explained.

Two stands per motor — With two stands per motor as illustrated in Figure 7, the problem is a little different because the impact speed drops are caused by half-load increments and the steel is continuous between stands when the steel leaves stand A_1, and hence there is looping due to the sudden load drop on this stand. If the product is such that looping is injurious, the effect can be minimized by the use of low resistance and inductance, high inertia motors. On a mill of this type looping can be eliminated by high inertia when the bar enters and can be minimized though not eliminated when the bar leaves by the use of low resistance and inductance, high inertia motors.

Tandem multiple-strand rod mills — These mills, insofar as impact speed change is concerned, are similar in action to the single strand mill with two stands per motor just discussed. In the case of two strands, sudden load changes usually occur in half-load increments and consideration must be given to the effect of load removal as well as load application because one rod will ordinarily be in the mill and continuous between stands when the other rod leaves as well as when a similar rod enters. Figures 8 and 9 show what takes place. With reference to Figure 8, rod No. 1 is subjected to stretching as soon as rod No. 2 causes impact speed drop in stand A, and both rods are stretched as soon as rod No. 2 enters stand B and until stand B entry speed drops and becomes equal to stand A delivery speed. The stretching is not "stored up" so that the looping that occurs as S_{Be} swings below S_{Ad} is not fully taken out. The net effect is therefore to throw a loop. If the steady state speeds S_{Ad} and S_{Be} are equal both when rolling one rod and when rolling two rods, the loop will

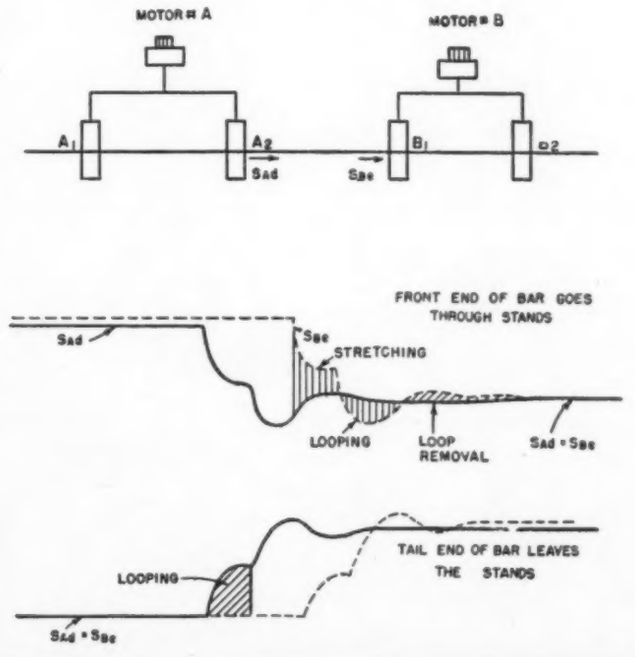
not come out automatically. If the material will stand stretching continually so that S_{Be} is slightly greater than S_{Ad} both when rolling one rod and when rolling two rods, the loop will come out automatically by such an adjustment.

With reference to Figure 9 the transient effect of rod No. 2 leaving the stands is to throw a loop in rod No. 1 which is only partially removed on subsequent swings. This type of looping can be minimized but not eliminated by use of high inertia, low resistance and inductance motors. The overall steady state loop thrown in rod No. 1 as a result of rod No. 2 leaving can be minimized by the use of motors having low resistance or by other means of obtaining good steady state speed regulation. If the product rolled is such that looping is injurious, low resistance and inductance, high inertia motors should be used. Separate flywheels have not been found necessary.

Steady state regulation is important because S_{Ad} and S_{Be} must be very nearly the same for two steady state conditions, namely, either with one rod in the mill or with two rods in the mill. The closer is the steady state regulation, the more nearly these conditions can be fulfilled without adjustment by the operator.

Examples of mills of the types under discussion are shown in Figures 10 and 11. One of these mills is straight away with stands 2 to 6 inclusive driven by a single motor and the remaining stands driven by individual motors. The other mill has both multiple strands and more than one stand per motor. This latter mill is a combination rod and merchant mill and has large loops on both sides of stand 13. Good steady state speed regulation of motors F, G and H aids in controlling these loops. These illustrations show the variation in mill layout which is encountered and illustrate why consideration must be given both to the product and

Figure 7 — Effect of a bar entering and leaving a four-stand mill with two stands per motor.



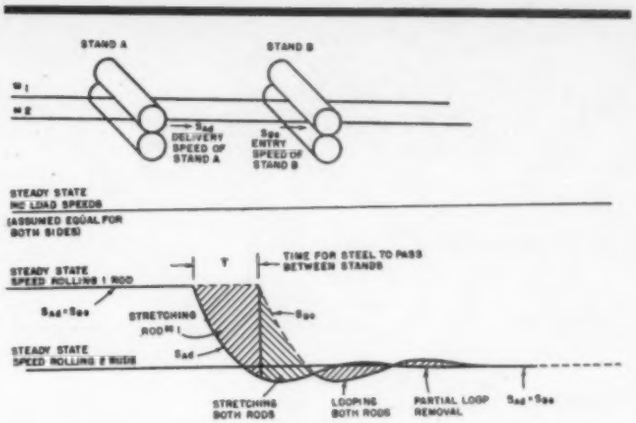

STAND A
STAND B
DELIVERY SPEED OF STAND A
ENTRY SPEED OF STAND B
STEADY STATE NO LOAD SPEEDS
(ASSUMED EQUAL FOR BOTH SIDES)
TIME FOR STEEL TO PASS BETWEEN STANDS
STEADY STATE SPEED ROLLING 1 ROD
STRETCHING ROD # 1
STEADY STATE SPEED ROLLING 2 RODS
STRETCHING BOTH RODS
LOOPING BOTH RODS
PARTIAL LOOP REMOVAL

Figure 8 — Speed regulation becomes quite complicated in multiple rod mills.

configuration of the mill to determine the most suitable motor characteristics.

Tandem tube mill — These mills are generally very closely coupled, that is, the stands are very close together and the tube shape is critical to ballooning. Moderate stretching is not harmful, but ballooning cannot be tolerated. The tendency to balloon can be eliminated by the use of flywheels so that the impact speed drop has no recovery and the transition from no load to full load speed is smooth. Figure 12 illustrates the action that occurs with sufficient inertia to accomplish this purpose. In order to minimize stretching, motors of low resistance are justified. Motors with high WK^2, low resistance and inductance, and even flywheels are recommended to prevent ballooning.

The sudden increase of load torque when the tube enters a stand is of particular concern because it produces impact speed drops which can cause ballooning unless critical inertia is used. Any subsequent load removal of a preceding stand by a succeeding stand is not of such great concern because this effect can only be produced by stretching of the tube.

For the purpose of analysis the effect of forces transmitted through the material in changing the shape of the impact speed drop curves is not shown, in the figures. The effect does not alter the analysis materially and is therefore neglected to simplify the problem.

USE OF SPEED REGULATORS

Speed regulators to minimize impact speed drop have not been generally applied, but calculations have been made to determine the transient characteristics that could be obtained by their use. A difficulty is presented in obtaining the required torque to minimize the impact speed drop quickly enough to appreciably affect the transient drop. There is an additional problem of stabilizing the regulating system so as to obtain response that is highly damped. Unless the transient as well as the steady state speed change can be minimized to a high degree, the speed regulators do not improve the performance and may actually accentuate the tendency to loop or balloon the metal between stands.

The calculations taking both speed of response and stability into account show that unless high inertia is

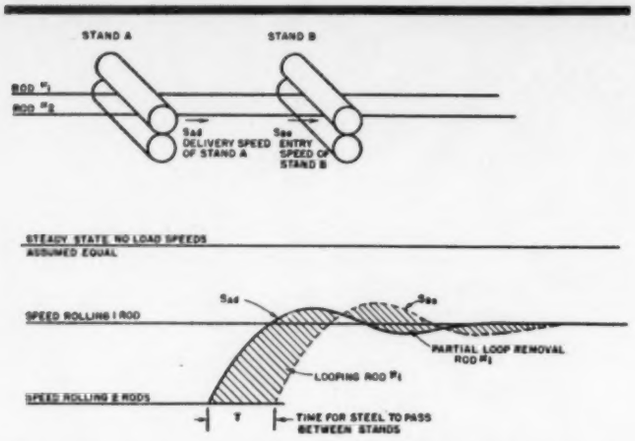


Figure 9 — It is essential that the motor speeds of both stands be very close to each other with either one or more rods in the mill.

used, speed regulators are ineffective, but if high inertia is used, in conjunction with a fast regulating system, the impact speed drop can be minimized as shown in Figure 13. In this figure are shown impact speed drops of a practical speed regulating system with the critical inertia and with double this amount. It can be seen that the use of a large flywheel plus a fast regulating system shows considerable promise in this regard. In order to accomplish this, considerable electrical equipment of special nature is required in addition to the large flywheel. It is therefore necessary to examine each application to make sure that the extra equipment is justified by the results before deciding upon its use.

BASIC FORMULAS FOR IMPACT SPEED CHANGE CALCULATIONS

Assuming the counter emf of the motor per rpm is constant, there are two simple equations whose solution shows clearly the transient behavior of the motor speed when changes in load occur suddenly. These are obtained by summation of voltage in the electrical circuit:

$$Ri+L\frac{di}{dt}=V-K_vS \qquad (1)$$

and by summation of torque acting on the motor shaft:

$$K_Ti=\Delta T+T_o+M\frac{dS}{dt} \qquad (2)$$

where R = resistance of motor armature circuit
L = inductance of motor armature circuit
i = current of motor armature
V = emf of the generator or power bus
K_V = motor emf per rpm
S = motor speed in rpm
K_T = motor torque per ampere
ΔT = sudden change in load torque (impact torque)
T_O = initial torque load
M = moment of inertia

When torque is in ft lb:

$$K_T=7.05\ K_V \qquad (3)$$

$$M=\frac{2\pi}{60}\frac{WK^2}{32.2}=0.00325\ WK^2 \qquad (4)$$

where WK^2 is in lb ft^2

The solution of the equations gives for the motor speed:

$$S=S_o-\frac{R\Delta T}{K_TK_V}-\frac{\Delta T}{2K_TK_V}e^{-\frac{Rt}{2L}}\left[(R+\beta)e^{\sigma_t}+(R-\beta)e^{-\sigma_t}\right]$$

where S_O = initial speed (5)

$$B=\frac{R^2M-L\,K_TK_V}{2LM} \qquad (6)$$

$$\sigma=\sqrt{\frac{R^2}{4L^2}-\frac{K_TK_V}{LM}} \qquad (7)$$

The transient component of this result is ocillatory if σ is the square root of a minus quantity. The physical meaning of this can be seen more clearly and the results applied more readily if the results are expressed in terms of the following time constants:

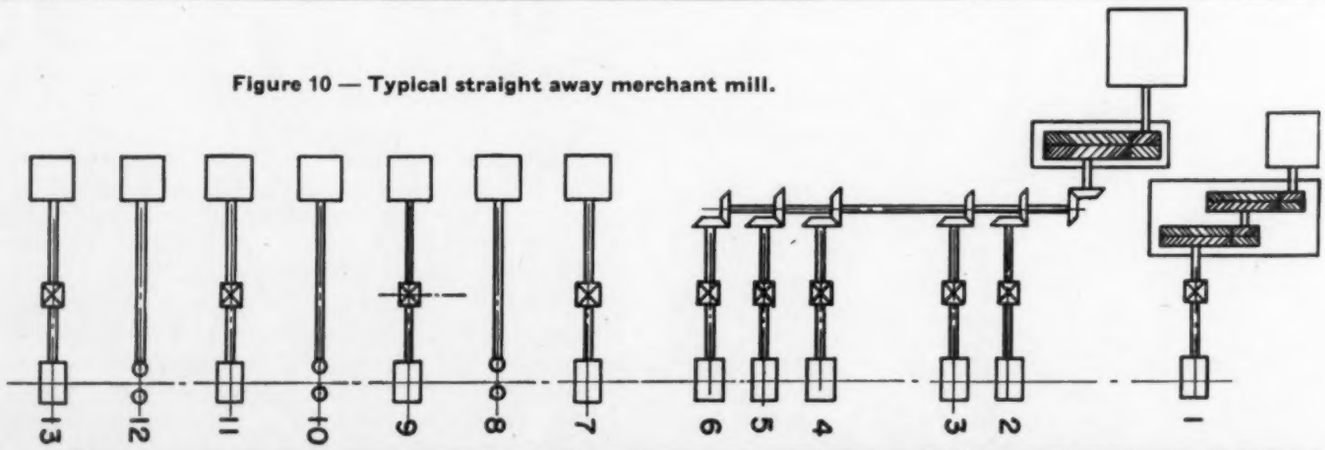
For the response of armature current:

$$t_i=\frac{L}{R}\ \text{seconds} \qquad (8)$$

For the response of speed:

$$t_S=\frac{MR}{K_TK_V}\ \text{seconds} \qquad (9)$$

Figure 10 — Typical straight away merchant mill.



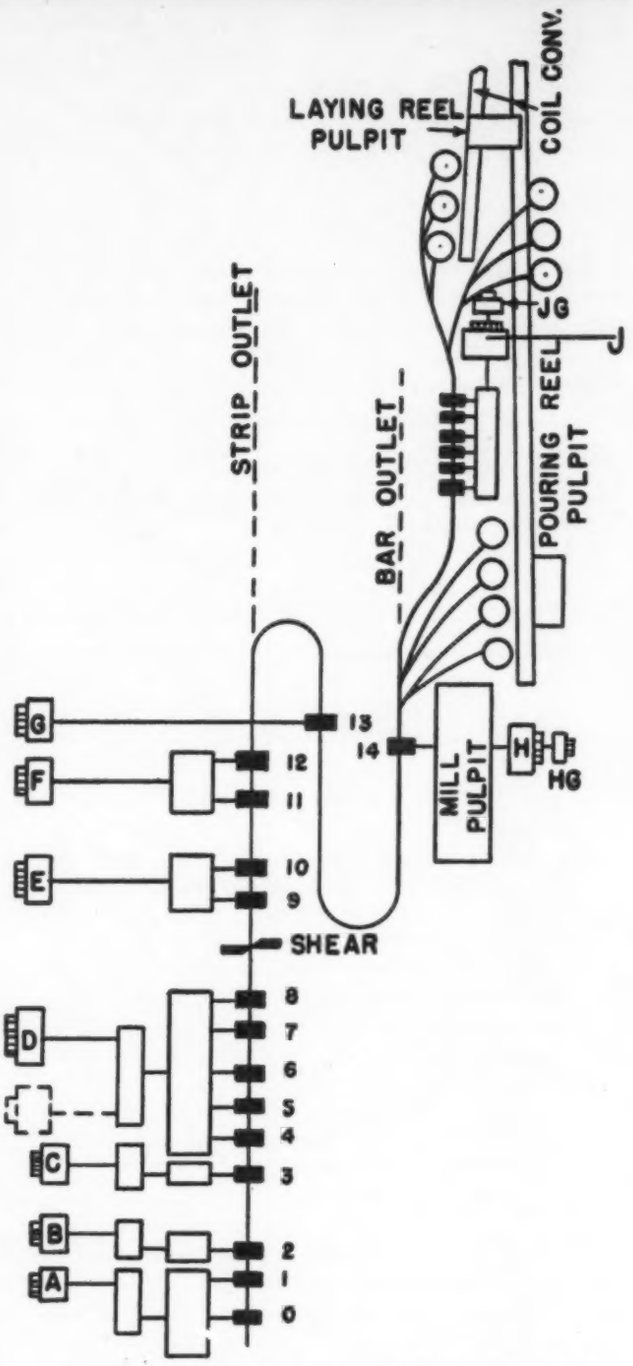


Figure 11 — Combined rod and merchant mill.

The first of these is derived from equation (1) on the basis that a change in speed can occur very fast (WK^2 is small). Then the equation may be rewritten:

$$Ri+L\frac{di}{dt}=V-K\triangle S$$

where $\triangle S$ is the speed change. It is evident from this that the time constant governing the current response is L/R or t_i. The second constant is derived from equation (2) considering that the current can change very fast (circuit inductance L is small). On this basis the equation can be written:

$$\frac{K_T K_V S}{R}=\triangle T+T_o+M\frac{dS}{dt}$$

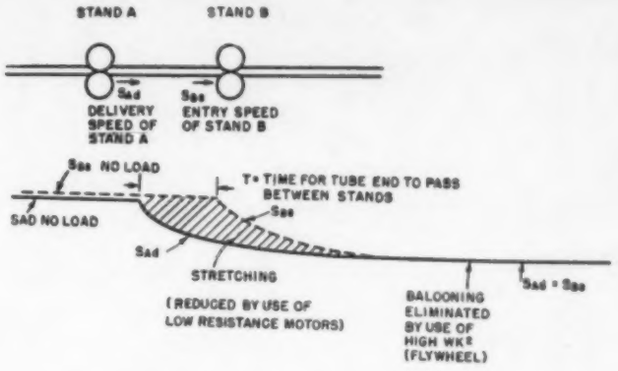


Figure 12 — Impact speed drop without recovery, eliminates ballooning on a tube mill. This type of speed drop can be obtained when WK^2 is equal to or greater than the critical value.

From this the time constant governing speed change for sudden change in load torque $\triangle T$ is $\frac{MR}{K_T K_V}$ or t_s.

In terms of these constants equations 6 and 7 may be rewritten as follows:

$$\beta=\frac{R}{2}\left(\frac{1}{t_i}-\frac{1}{t_s}\right) \tag{10}$$

$$\sigma=\sqrt{\frac{1}{4t_i^2}-\frac{1}{t_i t_s}} \tag{11}$$

Equation (5) will be oscillatory whenever

$$t_s<t_i \tag{12}$$

in which case it becomes:

$$S=S_o-\frac{R(\triangle T)}{K_V K_T}-\frac{\triangle T}{wM}e^{\frac{-1}{2t_i}}\sin(wt-\sin^{-1}wt_s) \tag{13}$$

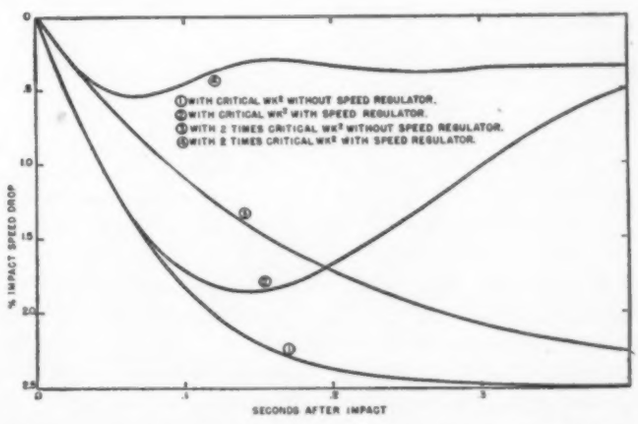

① WITH CRITICAL WK² WITHOUT SPEED REGULATOR.
② WITH CRITICAL WK² WITH SPEED REGULATOR.
③ WITH 2 TIMES CRITICAL WK² WITHOUT SPEED REGULATOR.
④ WITH 2 TIMES CRITICAL WK² WITH SPEED REGULATOR.
% IMPACT SPEED DROP
SECONDS AFTER IMPACT

Figure 13 — Calculated impact speed drop of 1500 hp, 375/750 rpm motor for tube mill when 100 per cent load is suddenly applied.

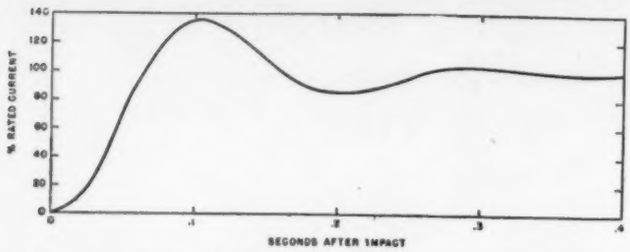


Figure 14 — Calculated current using speed regulator with 100 per cent load instantly applied.

where

$$w=\sqrt{\frac{1}{t_i t_s}-\frac{1}{4t_i^2}} \tag{14}$$

The transient speed change will be non-oscillatory whenever:

$$t_s \geq 4t_i \tag{15}$$

Substituting equations (3) and (4) in equation (9) and then substituting equations (8) and (9) in equation (15):

$$\frac{0.00325\ WK^2}{7.05\ K_V^2}\ R \geq \frac{4L}{R} \tag{16}$$

From this relation the critical values for the factors WK^2, R, L, and K_v can be determined. It is apparent that the circuit inductance should be low and the resistance high to obtain non-oscillatory transient speed change. Likewise WK^2 should be high.

It is useful to know the critical WK^2 for motors of normal design at any operating speed with rated terminal voltage. In this case,

$$K_v=\frac{V_r}{S_O} \tag{17}$$

where V_r = rated voltage
S_O = operating speed obtained by adjustment of field strength.

Substituting equation (17) in equation (16) gives for critical WK^2:

$$WK_c^2=\frac{8680\ L\ V_r^2}{R^2 S_o^2} \tag{18}$$

Another useful formula gives the critical WK^2 in terms of L and R where L is the average inductance of mill motors of normal design and R is per unit resistance. R is a decimal fraction of the ratio of rated voltage to rated amperes. The average inductance is given by dividing the rated voltage by the rated amperes and dividing again by the base speed frequency and again by 2π. The result is then multiplied by a coefficient representing the type or class of machine being considered. In this case for mill motors, $C_x=0.15$. Therefore,

$$L=\frac{V_r}{I_r}\ \frac{120}{S_b P}\times\frac{C_x}{2}=\frac{2.86}{S_b P}\times\frac{V_r}{I_r} \tag{19}$$

where S_b = rated base speed
P = number of poles
I_r = rated amperes

The resistance is:

$$R=R_M\frac{V_r}{I_r} \tag{20}$$

where R_M is a per unit (decimal) quantity.

Substituting (19) and (20) in (18) gives:

$$WK_c^2=\frac{18.6\times10^6\times hp}{S_b\times S_O^2\times P\times R_M^2} \tag{21}$$

Here hp is rated horsepower. This formula is useful for preliminary estimates. In practice less WK^2 than this is satisfactory as the speed swing is at low frequency and is eliminated for all practical purposes by inherent damping.

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DISCUSSION

PRESENTED BY

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A. L. Thurman: This paper will undoubtedly be of considerable benefit to the industry in planning future drives for many types of continuous mills. As the authors have indicated, low impact speed drop motors are not required for cold or hot strip mills, but for most other continuous mills, motors of special design with low impact speed drop are necessary for best performance.

One mill in which motor transient speed stability plays an important part is the tandem tube mill. The fundamental concepts explained by this paper are most important for a thorough analysis of the tandem tube mill problem, but some modifications should be made to the data furnished by the authors. For instance, experience has shown that the loading on any given stand motor can not be considered as constant throughout the time the tube is in the stand; extensive tests taken on a tandem tube mill when rolling under tension indicate that soon after the tube enters any given stand a high momentary peak load is produced. This peak load is of short duration but its value may be as high as 3 to 5 times the load which the stand will carry after

the tube has entered the next stand. This peak load can be explained by the fact that as the tube enters a given stand, as the authors have explained, it is traveling at a relatively lower speed than the peripheral velocity of the rolls; the tube thus must not only be reduced in cross-sectional area at that point, but it must also be accelerated to the speed of the stand. At about the time the tube enters the next stand, the motor load starts to decrease and soon reaches its steady state value.

As the paper has indicated, it is important for best tube mill performance to provide stand drives which will prevent ballooning between stands. The authors show that for a suddenly applied constant load, ballooning can be entirely prevented by the use of either critical inertia or critical motor armature resistance. Consider now the condition just described where there is first a low motor load, then a peak load and finally a reduced constant load. With this type of loading there is a tendency to produce ballooning at the instant the peak load starts to fall to normal rolling load. However, if the rolling schedule is such that the relative overspeed between stands is sufficient, then actual ballooning obviously would not occur, but at least during the instant described, the tension between the two stands in question will be decreased to the point where that portion of the tube will have to be scrapped; this condition generally produces a heavy end on the tube.

Since the use of only critical inertia or critical motor armature resistance will not entirely eliminate the tendency for the tube to balloon, it is well that the authors have considered the use of a very special speed regulator in conjunction with the proper amount of inertia to provide improved operating characteristics for tandem mill motors. It might be well to go one step further in this study in an attempt to provide the same type of speed change for the varying load described as that which can be obtained by the use of critical inertia alone for a suddenly applied constant load. In other words, an attempt would be made to bring the motor speed gradually to some definite reduced value after load is applied and then to maintain that speed by use of the regulator until the tube leaves the stand. This is not a simple problem, but it may deserve some study.

It would be still better if the type of operation just described could be obtained by the use of a speed regulator alone, since the addition of a large flywheel would be dangerous to any stand drive in the event of a serious cobble; it would be impossible to stop this high rotating inertia instantly without either wrecking the drive or breaking a shaft. Shear pins in the coupling could, however, be used as a safety measure for protection in the event of a bad cobble.

It might be of interest if the authors would comment on the feasibility of the type of control just described.

G. E. Stoltz: The authors have given a very thorough analysis of transient control of motors on rod mills. If I interpret their data properly, they have worked on the assumption that the motor should drop from its no load speed to its load speed substantially through its IR drop and settle to that value. As Mr. Thurman has said, that applies where we assume a load will be imposed on the stand that will remain constant throughout the time the metal is in the rolls.

There is an entirely different problem in applying motors to a tube mill where power will be transmitted by the metal from one stand to another. Furthermore, on this type of mill, the load may decrease or increase. In other words, the instant the metal is entered, there may be a momentary peak of a higher value than even the steady load, and then after the metal has entered the following stand, there will be stretching between these stands and the previous stand may be partially unloaded.

The type of control described mainly by the authors does not necessarily apply to this particular type of load. If these motors are simply allowed to settle down to their load speed, as long as the load remains the same, that is a very satisfactory method of control. But, if a little later, this particular stand is partially unloaded, then this same method will allow the motor to rise and leaves a fairly wide range of speed through which the motor can operate.

Under these circumstances, I think use of flywheel effect and regulation would be of advantage in order that a smaller range of speed would be obtained.

F. E. Crever and T. M. Linville: Messrs. Thurman and Stoltz point out that the actual load on any given stand motor will not be a constant load suddenly applied. In regard to this the authors wish to bring to attention two significant points.

First it is considered most important in the case of the tandem tube mill mentioned by Mr. Thurman to eliminate ballooning and to permit the speed change of each motor to be such that only stretching of the tube between stands results. Two explanations of load variation subsequent to the initial impact load have been made as follows:

a. The tube must be accelerated.
b. The action of a given stand lightens the load on a previous stand by transmission of force through the metal.

In the case of the acceleration load dropping off rapidly, the tendency to balloon will be greatly minimized by the means recommended in the paper. In the case of one stand unloading a previous stand it is obvious that stretching is involved and not ballooning.

The speed regulation characteristics for motors recommended in the paper are that the speed change in response to impact loads be non-oscillatory and be not greater than the steady state speed change for the same load. Motors with these characteristics, set for steady state speed regulation no greater than is needed to successfully operate the mill, offer the least likelihood of ballooning between stands, considering that the actual load on each stand is not constant. It is also important that stretching be a minimum, and this is accomplished by motors of the same characteristics, namely, low steady state speed regulation and equally low impact speed regulation. In the last degree, speed stabilizing regulators may be required as the paper points out.

The second point is the usability of the method of the paper in calculating motor speed performance when the load is not constant.

In a linear system, any form of load change may be represented by a series of abrupt load changes with good approximation. In the limiting case, when the form of load change is considered to be composed of an

infinite number of infinitesimal variations this becomes an exact representation. Formulae are available which may be applied to the results for the type of load considered in the paper to obtain the result for any other form of load change.

It would be gratifying to have more information on the actual torque loads on the individual motors on some of the existing tandem mills. In this regard it is insufficient to consider armature current as proportional to the load torque because of the inertia torque. Such data as is taken to be complete must allow means of obtaining the actual mechanical torque variation at the motor shaft.

With such data, additional calculations could be made that would be helpful no matter how confident we are that motors of low steady state speed regulation and equally low impact speed regulation, will greatly improve the performance of tandem tube mills.

It is worth mentioning that efforts to calculate stresses in the metal between stands (an extension of the paper) result in higher order equations which have no easily presentable solution. However, use of the differential analyzer promises interesting results should it be practical to carry the work further. The alternative is to get results with improved motors on an actual mill.

It may be well to point out that the only way to provide low speed change when sudden torque variations occur is to supply a counter torque of sufficient magnitude. Whether this is done by inertia or some other means is of little consequence insofar as the shock to the mill is concerned. Therefore a shear pin should be provided in any case to protect against excessive torques in event of a bad cobble.

TEMPERATURE SCALE OF THE BLOWING-TUBE BATH PYROMETER

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Kearney, New Jersey

▲ THE blowing-tube pyrometer has a true black-body temperature scale, and a nitrogen bubble at the end of the tube in the liquid steel also appears to closely approach a black-body radiator. Since a furnace melting chamber under certain conditions also approaches a black body, the same calibration setting will give true temperature in any such black-body radiator and also down in the steel bath, if a neutral gas such as nitrogen is used for purging the tube. With normal air purging, oxidation causes an error which increases linearly from a negligibly small value at about 2600 F, to about 65 F at 3000 F true temperature. This error appears to be consistent, however, for a normal range of air pressure on the blowing-tube. Furthermore, optical pyrometer readings on most of the common grades of carbon steel appear, strangely enough, to deviate from true temperature in very nearly the same manner. The evidence indicates that the usual effective emissivity for open streams (red radiation — 0.65) increases from about 0.40 at 2600 F to about 0.50 at 3000 F, causing average optical readings corrected for the usual assumed emissivity of 0.40 to deviate from the true temperature in very nearly the same manner as that for the blowing-tube, which explains further the basis for the results in Table I, which are given in degrees Fahrenheit.

As long as the correction to an optical pyrometer reading on liquid steel streams in the open remains based upon the accepted average emissivity of 0.40, there would seem to be no need to apply the correction for air purging on the blowing-tube temperatures. Present data indicate that bath temperatures by thermocouple and blowing-tube measurements, if corrected to true temperature, will be from 35 to 65 F low as compared to the tapping or pouring temperature scale now used in most steel plants. This poses a problem for general consideration, since there are a few advantages in the use of a true scale of temperature.

TABLE I

Bath pyrometer, F	Total radiation pyrometer, F	Optical pyrometer, F	Remarks
2788		2785	Flame on
2890		2885	Flame on
2910-2922		2905-2915	Flame on
2894		2890-2892	Flame on
2905-2922		2915-2910	Flame on
3003		2995	Flame on
2970	2977		Flame off
2950	2955		Flame off
2900	2906		Flame off
2800	2810		Flame off
2790	2792		Flame off
2780	2780		Flame off
2760	2767		Flame off
2750	2755		Flame off

Condensation of paper presented before American Institute of Mining and Metallurgical Engineers, Cincinnati, Ohio, April 21-23, 1947.

MACHINERY for ROLLER LEVELING FLAT ROLLED METAL

. . . . the variation in range of thickness which can be leveled by a given roll diameter has been theoretically set by some engineers as about 100 per cent . . . . this is a much narrower range than is accepted in general rolling mill practice . . . .

By A. J. WARDLE, JR., McKay Machine Company, Youngstown, Ohio

▲ ROLLER levelers have been used for mechanically straightening and leveling flat rolled material since the 1860's. The first machine of which we have a record consisted of a three-high roll arrangement for pulling the sheet through five staggered leveling rolls, with three leveling rolls on the top bank and two on the lower bank. The two lower rolls were operated by a foot lever which applied the flexing to the sheets while straightening.

The style of the roller leveling machine was not altered materially for quite a long period of time, except for minor changes and refinement in manufacture, and the addition of leveling rolls. The number of leveling rolls was increased from time to time until the number seventeen was finally adopted as standard for light sheet metal. Heavy plate leveling machines have never required as many staggered rolls because the material is very rigid, due to the increased thickness.

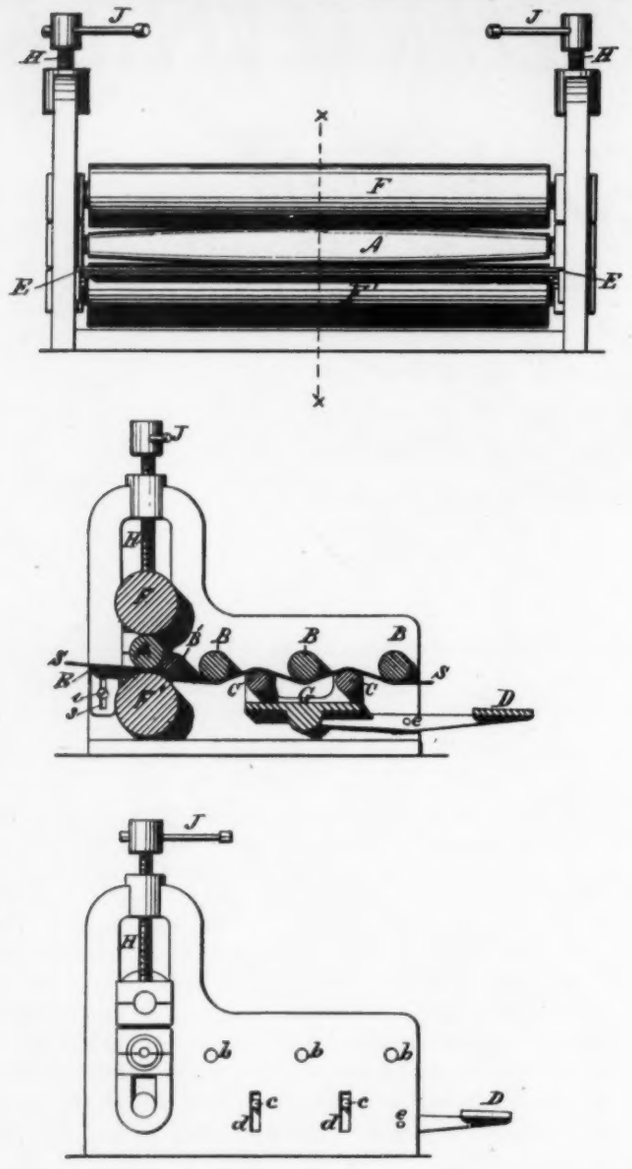
About 1925, the universal driving arrangement was generally accepted as the standard means of driving the leveling rolls, and was applied to each of the individual rolls in the roller leveling machine. This, no doubt, was the greatest improvement in roller leveling machines in many years. Before the universal drive was applied to the leveling rolls individually, the rolls were driven by gearing applied directly to the end of the roll necks, and as the top and bottom rolls were adjusted toward or away from each other, to cause more or less flexing of the material, the teeth in the gears on the roll necks were moved away from the pitch line and would cause excessive wear of the gear teeth. However, improvement in the roller leveling machines has been rapid since then.

About 1926, a worm driven leveling machine was developed which consisted of any desired number of staggered leveling rolls, and was similar to the other roller leveling machines, except in the drive. Each roll was driven through a worm gear, attached to the roll neck, and connected to a worm cut integral, with shafts which had the same number of worms as there were rolls in the lower or upper roll train. The worm shaft, driving the upper train of rolls, was contained in the upper roll housing and the worm shaft driving the lower train of rolls was carried in the lower housing. These two worm shafts were operated in anti-friction bearings and an oil-tight case, and were driven through sprockets and silent chains. The worm drive levelers operate smoothly and stand up well under ordinary conditions. They are used quite extensively on the lighter gauges of sheets.

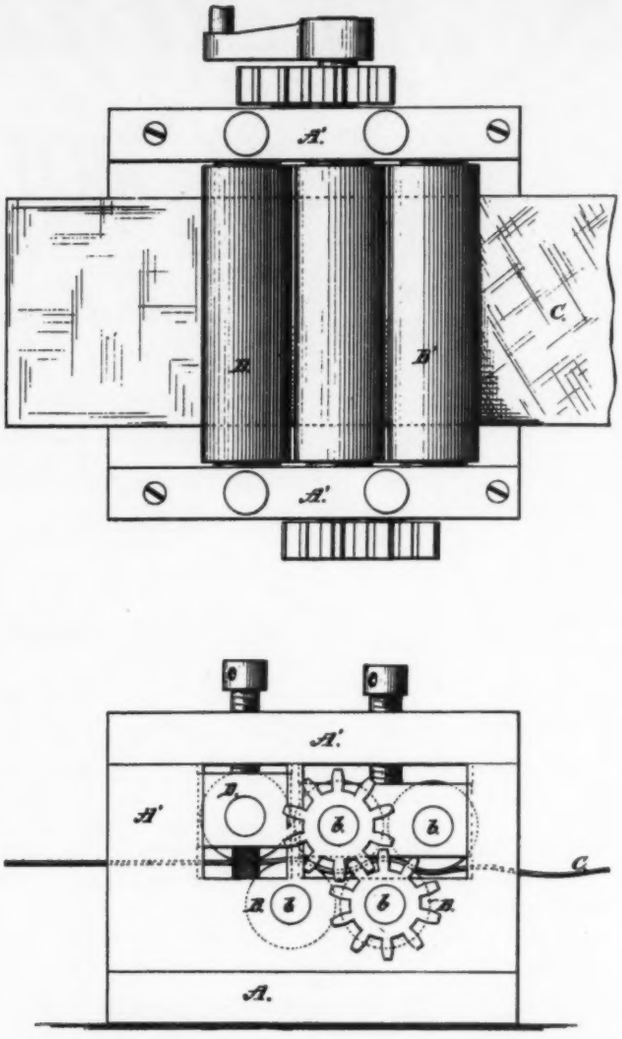
The earliest record we have of the backed-up, or 4-high leveler being used is about 50 years ago when Mr. Frederick Erdle of Rochester, New York built and operated a backed-up, or 4-high roller leveler. This leveling machine consisted of the regular staggered leveling rolls, which were supported midway between the roll housings by backing-up rolls. However, the backed-up roller leveling machine did not come into use in the rolling mills until the early 1930's, and since then has rapidly displaced the 2-high roller leveler in many operations. However, the 2-high leveler is still being used in some operations in nearly all flat rolling mills, especially in plate mills where the material is leveled hot and does not require severe flexing to lay it flat. It is quite necessary that a 2-high leveler be used on hot material, as the heat would draw the temper from the alloy rolls, which would have to be used in backed-up leveling machines. Another reason for using the two-high leveler on flattening hot material is that excessive scale is flaked from the plate as it is flexed in the roller leveling machine during the flattening process.

With the appearance of the backed-up leveler, it soon became apparent that rolls of smaller diameter

Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1946.



Patent drawing of first roller leveler, designed by Mr. C. Marshall in 1876.



Another old roller leveler is illustrated in this patent drawing.

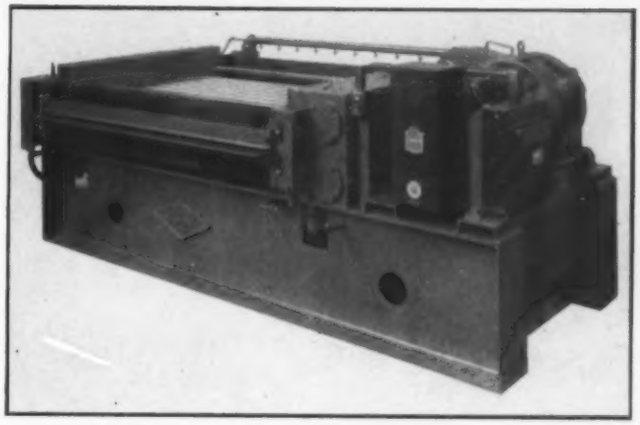
could be used than those which had been used in the 2-high machine. The backing-up rolls are generally made quite short and supported in anti-friction bearings, which are installed in rigid housings, that can be placed at intervals along the face of the work rolls. The backing-up rolls are placed in such a way as to support both the lower and upper train of rolls. The backed-up levelers are rigidly constructed because very heavy supporting members can be used to carry both the upper and the lower roll trains. The housings which carry the working rolls and which support the backing-up rolls can be made from castings or structural members of sufficient strength to prevent the backing-up rolls from yielding under the pressure of the working rolls while the material is being flexed. Backed-up roller levelers are being used with rolls ranging in sizes from about 1½ up to 20 in. diameter or even heavier.

The limiting factor in the capacity of the backed-up leveler is met, generally, at two points. First, the size of the driving gears and driving shafts is limited in diameter according to the spacing of the rolls. When there are seventeen staggered working rolls, there must be an equal number of driving shafts with integral gears, nested into the drive case, and the amount of space must be determined by the spacing of the rolls. The bearings of the backing-up rolls, like the gears, are controlled also by the size and spacing of the work rolls and must take practically the entire load of the working rolls. The backing-up rolls are generally about the same diameter as the working rolls and are short, so that from one to three or more sets of backing-up rolls may be spaced across the face of the working rolls. In shortening the backing-up rolls, two advantages are gained. First, it is wise to use as short a backing-up roll as possible, because the shorter the roll is made, the less it will spring when extreme pressure is applied. Second, when the backing-up rolls are short, a greater number can be applied, thus making it possible to increase the number of bearings which support the load. This is very important as the back-up roll bearings are highly stressed due to the very small diameter and shortness of the back-up roll bearings.

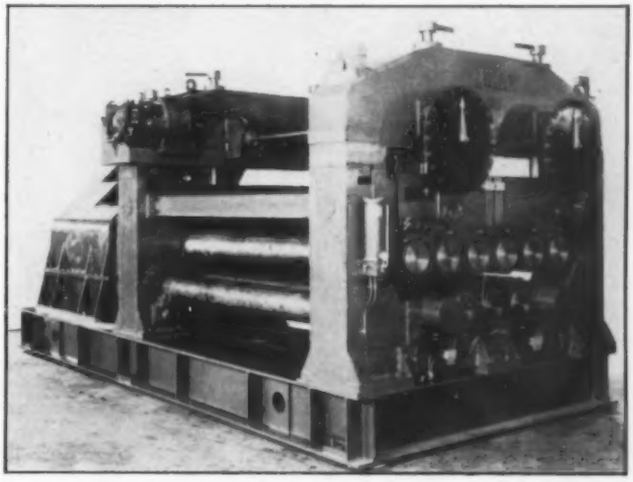
Twenty-five years ago, 80 feet per minute was considered about standard speed in roller leveling high finished sheets. The speed of leveling stayed at a maximum of about 150 feet per minute for any type of sheet until the wide strip rolling mill came into use. With the introduction of the wide strip mill, there was a decided step-up in the speed of rolling the wide strip, which soon displaced the highly finished cold rolled sheets that were produced in the 2-high and 3-high mills up to this time. As the speed of rolling strip increased, the speed of the roller leveler also increased until today, it is not uncommon for the roller leveling machine to operate at 400 feet per minute and in some cases, at a speed as high as 1000 feet per minute. The increase in speed has proportionately increased the work of the roller leveling machine and has caused greater stress to be met by the various parts which are unable to be increased in size due to the space in which they are contained. Here, I refer to the anti-friction bearings in the backing-up rolls and the gears, shafts, and bearings in the drive case. Since these parts cannot be increased in size, it is necessary that great care be exercised in improving both their quality and the workmanship done on them. The rolls in the backed-up leveler also have had to improve in quality, to add increased torque and hardness. As the greater loads are applied, the rolls, also, have to be considered, since the neck on the drive end has to carry the load if it is to drive the roll against the increased work. In the smaller diameter roll levelers, the rolls are now extremely slender and sometimes of considerable length. In some cases, backed-up levelers with 2½ in. diameter rolls have been built with more than 100 in. length of face. These rolls must be hardened to from 85 to 95 scleroscope and ground to finished size. Due to the small diameter and extreme length, these rolls are most difficult and hazardous to produce.

The gearing also has had to improve in order to stand up against the increased speed and load. The gearing of the high-speed leveler of today, must be made from material that is far superior to that which was formerly used in the lower speed machine. The gearing of today is generally cut in the form of either single helical or a herringbone tooth, and has a much finer pitch than was used in the old levelers. The gears and gear shafts are integral, carefully heat-treated to increase the hardness and toughness, so that they will stand up against the increased work. Gears in practically all of the roller levelers today are contained, with their driving shafts and bearings, within an oil-tight gear case and are fixed at the proper mesh of the gear teeth. The gears and bearings are flooded at all times with lubricant, either by the splash system or by pumping the lubricant. The rolls are driven from the gear case through universal driving bars. Comparable improvement of the adjusting mechanism has also been taken care of, as practically all leveling machines being built today are provided with accurately graduated gauges that show the exact movement of the rolls in adjusting the machine into or away from the path of the sheet that passes through the machine. The adjusting appa-

Standard universal roller leveler.



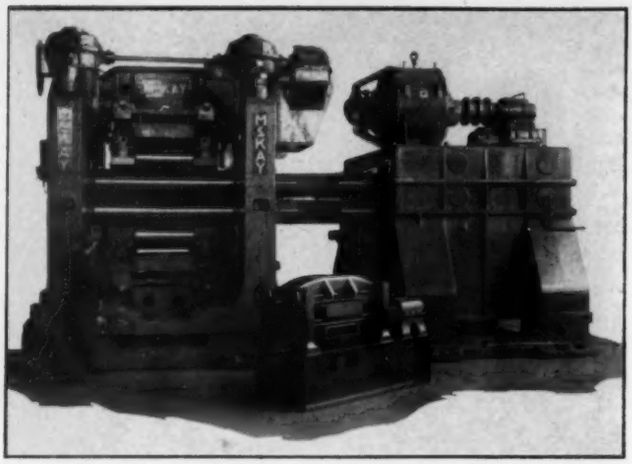
This standard roller leveler is driven through a worm drive.



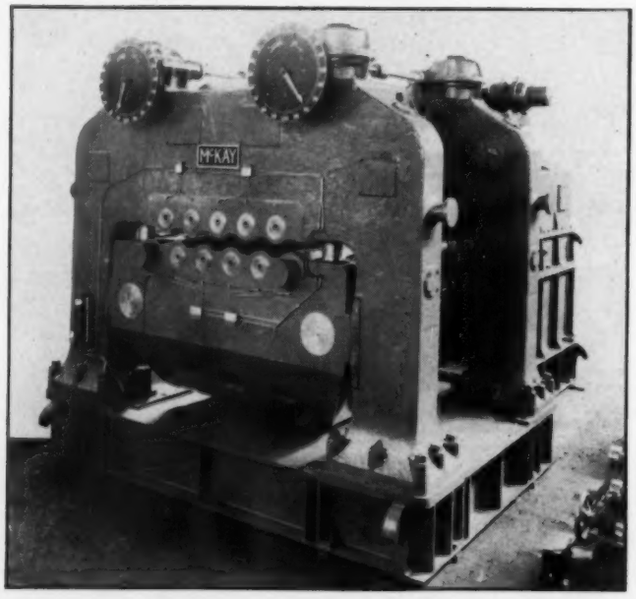
This leveler, generally used for leveling hot armor plate, has motor driven screwdowns.

▲

This backed-up type roller leveler has multiple sets of backed-up rolls to support the work rolls.



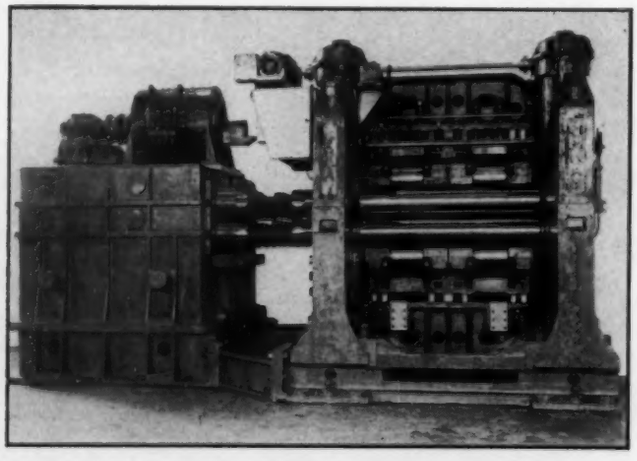
This 4-high, 15 x 60 in. heavy duty backed-up cold armor plate leveler, can handle ½-2 in. heat treated plates in widths up to 60 in. with delivery speeds of 33 to 66 fpm. The machine in the foreground is a 1⅝ in. backed-up leveler used for tin plate.



An inverted 4-high armor plate roller leveler with multiple sets of backed-up rolls. Note suspension of bottom rolls.

▲

Another inverted 4-high armor plate roller leveler.



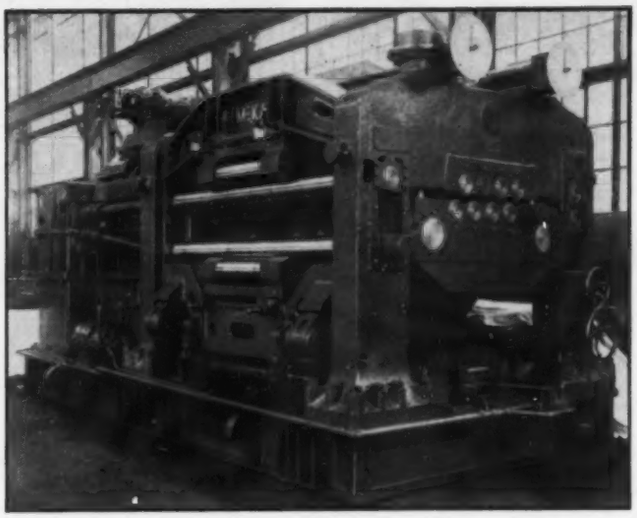
ratus is operated in the larger machines by power mechanism, although the smaller machines are usually operated by hand, generally through screws and nuts that are placed at the four corners of the roll housings.

PLATE LEVELING

Perhaps the greatest improvement in roller levelers, in very recent years, has been made in the heavy backed-up leveler for flattening heat-treated alloy steel. These were used during the recent war for straightening armor plate for tanks, and other vehicles. This light armor plate, as it was generally known, was flattened after quenching and drawing. In most cases, material ranging from comparatively light gauges up to 2 in. thickness and 70 in. width, when leveled cold after drawing, required the most abusive treatment, both of the plate and the roller leveler. The plates, when leveled, were not always flat enough to meet Government inspection as finished panels, but they were flat enough to go to the cutting tables, where they were cut into the proper shaped sections. The larger sections were brought back to the roller leveler and given one or more passes, and in most cases, were laid sufficiently flat to pass inspection. The plates, which were leveled directly as the plate left the draw furnace, and which were about 1000 F, were much easier to level and the resistance was relieved tremendously.

Another important improvement in roller leverlers, both in the 2-high and 4-high type machine, was made about 1940. At this time, an inverted type leveler came into use. In this type of machine, the rolls, with their backing-up mechanism and roll housings, are suspended within a "U" shaped housing, sitting on a common base with the drive. The adjustable weight in this type of machine is all suspended and adjusted by heavy screws, carried in large bronze nuts, that are arranged to freely swivel when the bank of the rolls is changed for a greater or lesser flexing of the plate. The stresses in this machine are all contained within the "U" shaped housings, and the only strain that is exerted on the base or bed, is the weight of the machine. The top bank of rolls is carried in the main "U" shaped housing and is not adjustable. The top backing-up rolls are carried by a rigid, fixed housing, attached to either of the main roll housings and they are adjustable. The lower bank of rolls is carried by a heavy girder-shaped housing, which also supports the backing-up rolls for the lower train, and is fitted into the main "U" shaped housing, so that it can swivel.

This lower roll train is held in position by hardened wearing plates that can easily be taken up in case of wear. One of the main advantages in this type of leveler is the absence of back-lash, caused by wearing of parts, such as the adjusting screws, nuts and other joints. In the inverted type machine, there is no necessity for springs, counterweights, or any other means of taking up wear, which prevent slapping as the plate enters the rolls. Here the drive is practically the same as in the conventional type machine, driving through universal drive bars to a common gear case, where the driving gears and spindles are contained in a gear case



This inverted back-up roller leveler has hydraulically toggle operated pinch rolls.

similar to that used on the standard universal driven leveler.

Another feature of the heavy levelers for flattening armor plate was the application of hydraulically operated pinchrolls on the entry side of the leveler. These pinch rolls, which had an opening of about 12 in., were operated hydraulically, and acted as a means of crushing the end of the plate as it entered the staggered rolls. These plates, as has been mentioned before, in some cases were badly cross-bowed. Under such conditions, they could not be entered into the leveling machine. However, with the rigid hydraulically operated feed-in rolls, it is possible to have the opening between the crushing rolls big enough to receive the plate in the bowed condition and if enough hydraulic pressure were used, the plate could be crushed down flat enough to enter the straightening rolls.

CAPACITY OF THE ROLLER LEVELERS

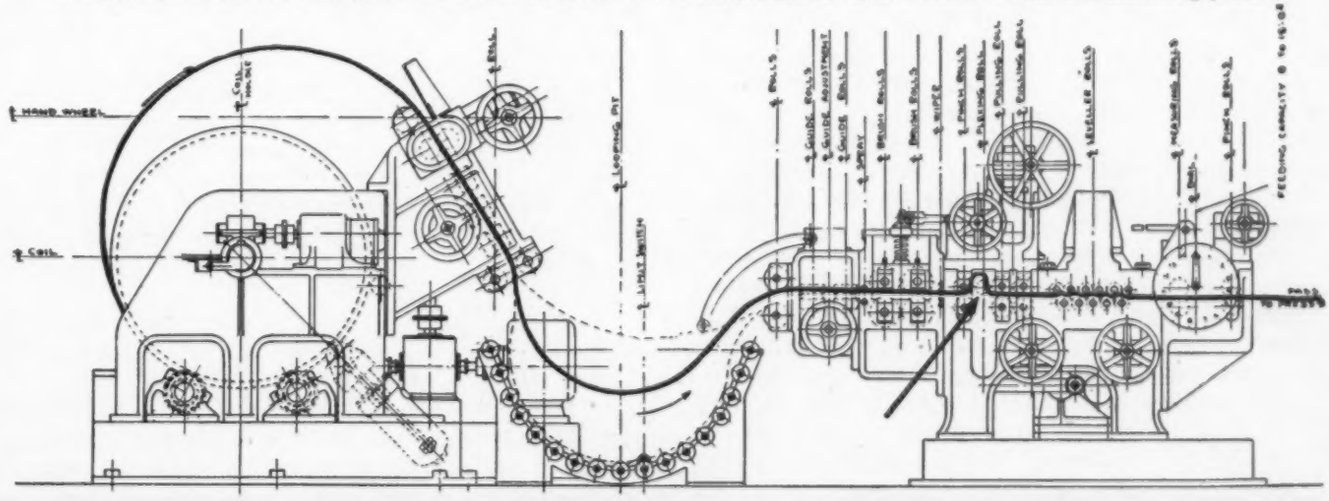
What is the capacity of a roller leveler? In the 2-high machine, plates and sheets of a wide range in thickness can be passed through the rolls without too much trouble, once the machine is properly set for the thickness of material which is to be leveled. If the setting is not sufficient to lay the material flat, the machine is re-adjusted to do more work on the sheet, and the sheet is put through again. On the other hand, if the sheet is getting too much work, the rolls will spring and will not materially damage the machine.

In the backed-up leveler, the work rolls, which are rigidly supported by backing-up rolls, are held firmly in the path of the sheet. Since they are not permitted to spring away from the sheet or plate, the adjusted setting of the rolls is much more important and must be very carefully handled. Since the backed-up rolls are not allowed to spring, a great deal of damage can be done if they are not properly adjusted. This is particularly true where the work rolls are set too close to permit the sheet to thread itself through the sinuous path of the staggered rolls.

The back-up machines are nearly all equipped with adjustment gauges that show the setting of the work rolls and permit the operator to know the exact opening between the work rolls, before the sheet is entered. One of the popular inquiries that the builder of roller levelers receives, reads, "Please furnish one roller leveler that will commercially flatten cold rolled, high-finished steel sheets ranging from 30 gauge to $\frac{1}{8}$ in. inclusive, from 32 to 72 in. in width." The first question to be decided is, can this variation in thickness be leveled successfully in one machine? If not, how many different size machines should it require? A roll diameter that is sufficiently large and strong enough to level a $\frac{1}{8}$ in. sheet is far too large to successfully level a 30 gauge sheet. If the buyer insists that he will purchase only the one machine, then there is only one safe position for the builder; i.e., to build a machine with sufficient stability to successfully level the heavy sheet. Now the question arises, how many different sizes it would require to successfully roller level the spread in thickness from $\frac{1}{8}$ in. to 30 gauge. The variation in range of thickness of the sheet in relation to a given leveler roll diameter is theoretically

(*Please turn to page 68*)

This processing press feeding line takes the strip from the coil, processes it, and feeds it into the blanking press.



Personnel Selection and Job Training

. . . . shortages in personnel, particularly in the skilled classifications, can be reduced by proper training programs . . . .

By W. J. McGLOTHLIN, Chief, Training and Educational Staff, Tennessee Valley Authority

▲ THE importance of careful selection of personnel, whether in private industry or the public service, cannot be over-emphasized. The success of any concern in the conduct of its affairs is, in the final analysis, dependent upon the people who comprise the organization. Congress recognized this when it designed the statute creating the Tennessee Valley Authority. It stated: "The Board shall, without regard to the provisions of Civil Service Laws . . . appoint such managers, assistant managers, officers, employees, attorneys, and agents, as are necessary for the transaction of its business . . ."

"In the appointment of officials and the selection of employees for said Corporation, and in the promotion of any such employees or officials, no political test or qualification shall be permitted or given consideration, but all such appointments and promotions shall be given and made on the basis of merit and efficiency."

You can understand from this that Congress intended to give TVA considerable freedom in the selection of personnel, and placed heavy responsibility on TVA management for establishing and maintaining a system of personnel administration based upon merit and efficiency.

Let us first take up the matter of recruitment and selection of personnel. Applicants are recruited from geographic or occupational areas as wide as necessary to assure obtaining well qualified candidates. Recruitment for administrative positions, for example, is done on a nation-wide basis, whereas construction labor is frequently recruited locally where the labor supply within commuting distance of a project is sufficient to meet project needs.

Under TVA's procedure, persons wishing employment may apply at any time. Important sources of recruitment include colleges and universities, recognized employee organizations, and TVA supervisors and other employees. Persons who voluntarily apply because of a desire to be associated with TVA also constitute a significant source of new personnel. To be employed by TVA, a person must not only be able to do a job, but must meet eligibility requirements. These have been kept to a minimum to avoid artificial restrictions on who may be employed. For example, candidates must be citizens of the United States or citizens of nations allied with the United States during war; they must be over 18 years of age and must meet the terms of TVA's nepotism policy.

TVA tries to make sure that every employee selected is the one best fitted for the job among candidates available to TVA at the time. To do this, the personnel department compares job requirements stated on a detailed job description with evidences of qualification such as training and experience, records of progress in previous employment, replies to reference inquiries, and for certain positions, test results. The department certifies a small group of candidates to the supervisor who makes the final selection. This process is followed, of course, within the framework of the Veterans' Preference Act of 1944.

Test results are never used as a sole measure of competence. Some tests are used to measure capacity for learning job skills through informal on-the-job training or through formal training programs. Such tests proved especially useful during the war years when greater emphasis was given to testing for potential ability, and tests were used largely for selection of trainees. Tests are now used to aid in selecting craft apprentices, clerks, public safety officer-trainees, chemical plant operator-trainees, student generating-plant operators, cartographic engineering aide-trainees, messenger and mail clerks. In addition, performance and clerical aptitude tests are given to typists and stenographers. Most tests used by TVA are constructed by the personnel department with the assistance of departmental supervisors who have first-hand knowledge of job requirements.

All the positions for which tests are used are at the lower salary grades, and most of the positions are in formal training programs. Here, TVA attempts to recruit people who are best able to profit from the training, but not necessarily those with training and experience in the field. The tests, therefore, are designed to measure aptitude rather than achievement. The lan-

Presented before the AISE Birmingham District Section Meeting, January 27, 1947.

guage of the tests is related to the jobs involved and is so written as to reveal interest in matters related to the work.

I should like to consider another method by which TVA maintains a high quality of personnel. Employment of the best qualified applicants available, important as it may be, does not present a final solution. One solution lies in the extent to which an alert management recognizes that efficiency and economy in its operations depend directly upon the knowledge, skills, and abilities of the people who comprise the organization. This brings us squarely to the subject of job training, for it is through training that these essentials are further developed.

In TVA, training is directed toward certain primary objectives. Briefly defined, these are, first, to increase the qualifications for and effectiveness of employees in their present work; second, to develop potential abilities which will permit employees to attain qualifications for promotion; third, to increase employee versatility so as to permit flexibility in work assignments; and finally, to provide employees with an understanding of its policies and program of the TVA so that their efforts may be guided by the objectives toward which the TVA directs its activities. The attainment of these objectives has significant results, not only in such tangible factors as increased skill and ability, but in the somewhat intangible, yet highly important factor commonly referred to as "organization fitness," "esprit de corps," or simply good morale.

The operating departments in TVA are directly responsible for developing and conducting training programs for their employees within the framework of established standards. The personnel department provides professional assistance in determining training needs, and advises departments on training methods and techniques. It also prepares materials for related classroom instruction.

The administration of employee training in TVA is an excellent example of the democratic internal relationships which exist between management and employee organizations. Recognized employee unions join with management in administering training programs in bargaining units where unions have gained the right of exclusive representation of employees. The joint committees which administer these programs are responsible for determining the number of trainees, planning the training, selecting the instructors, and examining the trainees. This responsibility does not extend to placement upon completion of training.

Management retains the responsibility for choosing from among graduates of the training programs and other qualified applicants in filling a vacancy. Since the unions help make decisions within the field of training, their representatives feel responsible for seeing to it that employees accept the decisions on training. If employees are dissatisfied, they are directed toward their representatives, not toward management. One high ranking TVA supervisor attributes the absence of dissatisfaction in his units to joint administration of training in which employees participate.

Most of the TVA training programs include both training on the job and related class work. The job instruction is carefully planned by developing detailed job analyses. These analyses list the various functions which the trainee is expected to master. Joint training committees develop the lists and determine how much time is to be spent on each phase of the work. Through weekly reports submitted by the trainees to the personnel officer, who keeps the records and makes the reports, the committee can readily determine whether a trainee is being held too long on one or more phases of the work at the expense of other phases. Instruction on the job is given by regular production workers and the trainee takes over increasingly difficult parts of the work as he progresses through the program.

The related class work is geared as closely as possible to instruction on-the-job. In class, the trainee learns the "why" of the work, whereas on the job, he is concerned with the "how." Trainees often bring practical job problems into the classroom where they are solved for the benefit of the group. Blueprints, manufacturer's bulletins, information pamphlets, as well as textbooks or specially prepared lessons make up the materials which are studied.

In some programs, it is necessary for us to design our own materials since the training is geared closely to job requirements which are sometimes peculiar to TVA work. For example, no appropriate materials were on the market for a training course in electric furnace design. The instructor, with the assistance of a personnel officer, went through blueprints and reports on furnaces previously designed and constructed, and developed materials which fitted the course precisely.

Training in TVA benefits greatly from a close relationship with educational institutions. Colleges and universities in the area have established accredited courses directly related to the needs of TVA employees. They have covered a wide variety of subjects including engineering, physical sciences, management, political science, etc. These were greatly expanded during the war under the engineering, science, and management war training program. University schedules in some cases were modified so that classes could be held at hours during which employees could attend. In some specialized courses, employees have acted as instructors.

Brief comments on certain of our programs are given in the following paragraphs:

1. Induction training programs have been established to provide employees with an understanding of TVA program and policies. In addition, employees are given information essential for an understanding of their jobs.
2. Over 200 supervisors of different levels in our plant at Muscle Shoals were trained in the various phases of supervision.
3. In the ten years of the craft apprenticeship program's operation, over 500 apprentices have reached journeymanship. At the end of June 1946, 130 apprentices were enrolled in programs covering twelve crafts.
4. Since the student generating plant operator program was originated in 1936, over 100 students have been trained as operators.
5. More than 3400 employees have been trained and examined for higher positions under the chemical plant operator program.
6. Approximately 220 draftsmen have been trained.

7. Special schools which provide full-time training for typists and stenographers whose skills do not fully meet TVA standards have been conducted since 1941. Four hundred forty-two stenographers and typists have received such training in these special schools.
8. Several programs have been developed in the field of management. These include training plans for personnel assistants and public management assistants, and an administrative work rotation plan.

This list is by no means complete, but serves to indicate some of the major types of programs which have been put to test. Of course, the great bulk of training in TVA or any enterprise is not to be found in formal training programs, but consists of the informal instruction inherent in good supervision.

There is no single measurement device which affords a satisfactory index of accomplishments achieved through training. Benefits will range all the way from increased skill in work performance to the development of a healthy employee outlook and an enthusiastic spirit of cooperation. In TVA, the importance of training was probably most concretely demonstrated during the war at a time when trained journeymen, hydro plant and chemical plant operators, laboratory technicians, and the like, were not to be found on the open labor market. Without training programs, staffing TVA adequately through those difficult times would have been nearly impossible. I do not mean to suggest that we have by any means used training to its fullest extent. However, we are convinced that our experience has amply demonstrated the effectiveness of training, and we expect to see its further development in postwar work of TVA.

MACHINERY FOR ROLLER LEVELING FLAT ROLLED METAL

By A. J. WARDLE, JR.

(*Continued from page 65*)

comparatively narrow. Some engineers have determined that a variation in thickness in sheet of 100 per cent is about the range that can be properly covered by a given diameter roller. This, of course, is a far narrower range than is accepted in general rolling mill practice on the lighter gauges of sheet.

The last type of roller leveler which we wish to discuss is the sheet processing machine for relieving stretcher strains from the sheet prior to drawing. Dr. G. L. Kelley, chief metallurgist at the Edward G. Budd Company, Philadelphia, Pennsylvania, applied for patents on a machine for preventing the formation of stretcher strains during the process of drawing sheet metal to form auto body parts. This machine was a very distinct improvement over the standard type of roller leveler as it cold worked the sheets with a far greater amount of flexing than was possible to obtain in the standard roller levelers. Behind the first pair of feed-in rolls, there is placed what is called the flexing roll, which is kept as small in diameter as can be worked successfully. This flexing roll is automatically operated and as the sheet passes between the first pair of feed-in rolls over the flexing roll and enters the second pair of pinch rolls, the flexing roll is automatically raised directly in the path of the sheet, causing the sheet to bend reversely around the feed-in rolls and the flexing roll. It is then passed on through the staggered leveling rolls for straightening. This severe cold working has proved very effective in relieving strains. In 1933, permission was given to sell this machine to the stamping trade. The design and mechanical make-up was materially improved and it has been adopted as the standard method of relieving stretcher strains in the auto-body industry throughout the world.

A recent development in the use of roller levelers and processing machines in the automotive industry is the combination processing and press feeding line. This line consists of a power driven coil box for uncoiling the strip, cleaning rolls and a processing machine for cleaning the strip and removing strain, and a press feeding and measuring device for feeding the strip directly into a blanking press.

DISCUSSION

PRESENTED BY

W. D. SHIELDS, Edward W. Voss Company, Pittsburgh, Pennsylvania

A. J. WARDLE, SR., President, McKay Machine Company, Youngstown, Ohio

W. D. Shields: I would like to ask if there is any relationship or any reason for putting the most leveling rolls on the top flight or on the bottom flight?

In your figures, sometimes you have more leveling rolls on the top flight and sometimes more on the bottom flight, and I was wondering what was the reason for that arrangement.

A. J. Wardle, Sr.: The reason for putting the greater number of rolls on the top bank was originated, when the plates were brought to the roll leveler on trucks.

The pile on the truck was generally lower than the rolls on the feed line into the leveling machine. Consequently, the sheet was coming up on an incline at the time it arrived at the feed-in rolls, and the top, upper roll overlapping the bottom one gives the sheet a chance to enter freely without holding the sheet up and tipping it.

EFFECT OF SULPHUR BACTERIA ON CORROSION . . . .

. . . . bacteria have a marked importance to mankind in many more fields than that of medicine which is the one normally considered . . . . corrosion and oil deterioration may be charged against them . . . . on the beneficial side, sulphate reducing bacteria may increase oil production markedly from exhausted wells . . . .

By L. LIBERTHSON, Director, Patent Department, L. Sonneborn Sons, Inc., New York, New York

▲ ABOUT two years ago, the writer was involved in an investigation of a problem which at least in one case had taken on the aspect of a major nuisance, to wit, the deterioration of large volumes of cutting oil emulsions, resulting in operative difficulties and economic losses of considerable magnitude.

For the purpose of a rapid review, it will be useful to refer to the outstanding details as published in Lubrication Engineering, December 1945, in an article "Bacterial Deterioration of Cutting Oil Emulsions." In this paper, a case was described in which thousands of gallons of cutting oil emulsions were lost because they spoiled in storage; briefly, the emulsion turned black, emitting H_2S and finally split into the component oil and water phases. Investigation of the actual physical conditions of storage and distribution of the emulsion, after it had been clearly established that the soluble oil itself as well as the "base" from which the emulsion was made, could not be charged with responsibility for the deterioration of the emulsion, led the writer to suspect that he was dealing with a case of bacterial action in which the specific organisms taking part were anaerobic in character. Furthermore, since the evolution of H_2S was definitely a characteristic of the deteriorative process, it seemed logical to conclude that the organisms were of the sulphur reducing type. Accordingly, aeration of the emulsion was suggested as a means of rendering the medium hostile to the functioning of the bacteria. This measure was, in some cases, mainly successful and had, as a matter of fact, been resorted to in at least one instance as a sort of empiric countermeasure. In the course of the investigation, fairly elementary proof that the deterioration was bacterial in origin was evident from the fact that it was found possible to innoculate or infect fresh emulsions simply by introducing small amounts of the deteriorated material. In view of the fact that aeration of large volumes of the emulsions running into thousands of gallons was often impracticable, due to lack of equipment, it seemed logical, especially in view of the ease with which good emulsions could be infected, to institute a search for specific inhibitors as a means of avoiding spoilage.

Included in the type of inhibitors investigated and found potent, were organic and inorganic hypochlorites, organic mercury compounds, the latter most likely acting by combining with the sulphur-hydryl groups of the bacterial proteins, phenolic and poly-chlorinated aromatic compounds and even straight chlorination.

It was, however, open to question whether a more sensible approach toward avoiding bacterial deterioration were not to prevent initial infection rather than to contend with micro-organisms after they had "taken over."

Presented before AISE Annual Convention, Cleveland, Ohio, October 4, 1946.

For industrial establishments in which cutting oil emulsions are stored in large quantities as, for instance, in cases where such emulsions are pumped through a circulating system over relatively large working areas, it is urged that absolute cleanliness and sterility are probably the best guarantee against infection. It is only where the latter does take place and aeration is not practical that we should resort to the use of specific inhibitors.

INDUSTRIAL MICROBIOLOGY

Detailed excursion into the field of industrial microbiology would obviously be a major project even if it were undertaken with reference to corrosion alone. The subject as a whole is of vast interest and it is no exaggeration to characterize recent advances in that field as nothing short of revolutionary.

Bacteria have, for generations, been associated with the causation of disease and hardly anything else. Indeed, bacteriology is, to the vast majority of people, regarded as exclusively a branch of medicine; just as, further up in the biological scale, the pathological aspects of mycology have received far more attention than the industrial and synthetic aspects. Yet today, huge industrial plants embracing a vast spectrum of processes are based on the harnessing of bacteria and fungi to yield enormously valuable products and by-products. When we take note of anti-biotics such as penicillin, streptomycin, and industrial organics such as butyl alcohol and citric acid, it is easy to realize how far flung are the possibilities real and potential, of applied microbiology. And the evidence is very great that even so we have only tapped the surface.

One reason for the elements of surprise and novelty in the field lies, of course, in the fact that we are essentially dealing with a microscopic universe, a cosmos under a lens, a chain of biologically induced and governed reactions in a drop of water, all of this presenting a challenge to the scientist, a challenge that he has met, namely, to tame the microorganisms involved and to control their biological habits.

The reader may recall the fascinating story by Sir Fitzhugh James published many years ago called "Under the Lens." It deals with the case of a scientist who discovered a microscopic form of human life, specifically a perfectly formed female creature, in a drop of water. Sir James went on to relate what happened when this tiny creature consumed all the nutriment it, or she, required and how frantic and ultimately deranged the scientist became when he could not replenish it and the creature died.

The fantasy is not as far fetched as it sounds, in the light of what we know today. That part of the bacterial world, vast as it is, which is familiar to the pathologists, is only a small corner in the microscopic kingdom, and in view of what the electron microscope is revealing today, this corner itself becomes even smaller and becomes only the pathogenic branch, the weeds in the microscopic plant kingdom, in which the total membership contains species of vast potential benefit to the human race.

For there are bacteria (recall, for example, the Metchnikoff discovery of the bacillus bulgaricus) which are very likely even more than merely beneficial, but are actually essential to health, in fact capable in themselves of yielding as by-products of their metabolic cycle, an untold series of known and possibly unknown essential vitamins. Thus, for instance, (1)* VanNiel, in an extended review dealing with chemoautotrophic bacteria (the generic term applying to microorganisms that can exist and grow in a mineral environment without light and air) observed that thiobacillus, thiooxidans, the cell structure of which has been found to be essentially similar to that of non-sulphur organisms (1a) can synthesize practically the total vitamin B complex from an inorganic sulphur-containing medium. Rather cryptically the author observed that the organism, therefore, "is far from primitive."

If anything, this characterization of that organism is an understatement for when we realize how many organic chemists and how many thousands of hours and what complicated equipment it has taken even to resolve vitamin B complex into its individual components, one may well gape and wonder that a single microorganism is capable of accomplishing the entire job in the course of its daily life cycle. By comparison, it is we, indeed, who are primitive.

Bacteria are known which are capable of forming ascorbic acid from sugars (2). It is easy to imagine that with single organisms performing specific functions, the same type sub-relationships exist as between higher forms of life. There are antagonisms wherein one microorganism will crowd another, bringing into operation the same principle of survival of the fittest as is observable on higher biological levels. There are also symbiotic relationships where one species helps another and parasitic relationships where one species will breed at the expense of another.

However, while the above observations are provocative in themselves, the engineers' specific interest lies within their own field of experience. Let us then turn to those microorganisms which are known to function in our own work, namely, sulphur reducing and sulphur oxidizing bacteria; and we shall not overlook, parenthetically, hydrocarbon bacteria which it might be more accurate to call petrophilic, than by any other name. For these organisms decompose hydrocarbons to water and CO_2, and the latter is a definite contributing factor favoring the propagation and metabolism of the sulphur bacilli.

CHEMOAUTOTROPHIC BACTERIA OF INTEREST TO THE ENGINEER

To the reader who is perhaps not familiar with the author's earlier paper on the subject, it may be helpful to pass quickly through some of the references in that paper which bear particularly on the subject of corrosion. Recent contributions in the Oil and Gas Journal (3), relate to the corrosion of water sealed gas holders due to H_2S present is a result of bacterial action. Similarly, investigation of means of preventing corrosion of underground pipe lines and cables has led to the recognition of sulphur and sulphate reducing bacteria as a contributing agent.

Within the past year, the author has had occasion to extend his acquaintance with the subject in his efforts to detect examples of the invasion of the organ-

* Numbers refer to bibliography at end of paper.

isms under discussion in the field of rust inhibiting compounds, where failures of the latter could be explained in no other way. The subject is receiving considerable attention in Pennsylvania. For example, (4) in 1943 Proceedings of the Annual Water Conference of the Engineering Society of Western Pennsylvania, one contribution disclosed that the fouling of pipe lines by bacteria, both aerobic and anaerobic is frequently accompanied by corrosion. Among the combative measures suggested were: elimination of the source of nutrition, or killing the organisms, or both. As an effective means of eliminating all types of organisms, chlorination was suggested. A comprehensive review (5) with 15 references from this source appeared in their 1941 proceedings, in which the role of sulphate reducing, and conversely iron consuming, bacteria is detailed in the corrosion of iron pipes. In several issues (6) of the Oil and Gas Journal in 1943, various tests are described which may be resorted to in the detection of the presence of anaerobic bacteria having sulphur reducing ability. These contributions are accompanied by illustrations of the corrosion caused by the bacteria.

Again, in a recent issue of Power Plant Engineer (7), are reported many condenser tube failures which occurred when slime deposits fouled the tubes. Interestingly enough, it was noted that at various temperature levels, while some types of bacteria were destroyed, others became extremely active. Both sulphur and nitrogen compounds underwent reduction producing corrosive gases. This, in conjunction with the electrolytic effects due to various metals present, was held as providing the explanation for many tube failures. This is a particularly interesting instance because it very definitely illustrated some of the microbial relationships on the biological levels to which we referred earlier in this paper. Nitrogen fixing bacteria, for example, are very well known and, indeed, are the backbone of modern agriculture and yet we find them functioning side by side with sulphur reducing bacteria.

Another extremely interesting side light on the subject has emerged from "down under" last year. The Australian Journal of Experimental Biological Medicine reported (8) last year the discovery of five strains of sulphuric acid forming bacteria, isolated in pure culture from corroded concrete exposed to atmospheres containing H_2S. The five strains were dubbed as belonging to a species of thiobacillus concretivorus. The direct cause of the corrosion of the concrete seemed to be due to the development of sulphuric acid and production of calcium, iron and aluminum sulphates. All five strains were observed to grow in the presence of free sulphur and sodium thiosulphate and all were noted to be equally capable of oxidizing sulphur to sulphuric acid. They were isolated in large numbers from specimens of corroded concrete. They did not utilize H_2S directly but convert it to sulphuric acid, free sulphur or some other utilizable form of sulphur non-biologically produced. The relation between their life process and corrosion was closely studied and was found to be divisible into two stages: the preliminary stage in which carbonate — bicarbonate — CO_2 equilibrium is destroyed and the pH falls from about 8.5 to about 6; and a final stage in which active multiplication of the organism and acid formation take place.

With the additional quotation from Current Science (9) for 1943 relating to the isolation of an anaerobic organism which produced elementary sulphur when grown in a medium containing sulphates, it may not be altogether absurd to imagine that perhaps some day we shall not have to mine sulphur, but put certain bacteria to work at making it. As is unavoidable when one attempts to traverse the world of microbiology, trails cross and lead to unexpected vistas. We speak of sulphur reducing bacteria and eventually cross into the field of petroleum technology to find a direct connection. Thus, in the Journal of the Institute of Petroleum Technology (10), is to be found a recent discussion of evidence that the activity of bacteria in the water underneath gasoline and storage tanks is responsible for gum formation and consequent deterioration of the gasoline. The effectiveness of certain commercial gum inhibitors such as those which contain phenolic or polyphenolic groups is in part ascribed to their potency as anti-bacterial agents. This is a familiar field to every petroleum engineer; in fact, it is almost "exhausted art." Yet, here is a new angle involving bacteria as one of the responsible agents.

Microorganisms capable of utilizing petroleum hydrocarbons in their nutritional or metabolic cycles have, of course, been known for many years. The writer, indeed, was associated for some years with Dr. J. Tausz who is one of the pioneer contributors to the sum total of existing knowledge on the subject. But it was not until recently that the suggestion was made by Mr. Beck (11) of the Pennsylvania Crude Oil Association to turn that knowledge to a tangible desired end. Mr. Beck believes that strains of bacteria may be found and selectively bred which would be introduced into underground reservoirs to Pennsylvania paraffinic deposits and oil sand thereby reducing production costs.

The subject has even reached the newspapers. The New York Herald Tribune of May 28, 1946, published a small paragraph, in which it was noted that sulphur reducing bacteria are of great interest at present because it is possible that they plug the sand face of water input wells; and it notes that means are being developed for controlling these bacteria.

Perhaps more interesting than anything cited so far (12), however, is the case of the production of so-called "rubber acid", actually H_2SO_4, in rubber hose. This is now recognized to be due to sulphur oxidizing bacteria. Sulphuric acid will invariably form in rubber lined hose when it is stored with its lining wet and responsible bacilli are present, particularly when the free sulphur content in the rubber exceeds 0.1 per cent. Here the answer was found to be preventive. If the hose is stored dry and the free sulphur is below 0.1 per cent acid formation is effectively prevented, there being no practical way of excluding these sulphuric bacteria. Incidentally, in this instance, the manufacturer of organic sulphur compounds used for vulcanizing rubber was absolved since these compounds were found to be not accountable for acid formation.

SULPHUR BACTERIA AND THE CORROSION ENGINEER

It is necessary to refer again to the writer's earlier paper and particularly to the discussion therein of the role which sulphur bacteria conceivably play in the unfavorable experiences which are encountered from time to time with rust-inhibiting compounds and other

coatings designed to prevent corrosion of iron and steel.

Many such intendedly protective systems appear to provide environmental factors which favor multiplication and metabolism of sulphur reducing bacteria. Where there is sulphur in combined form, it seems to be altogether reasonable to suspect sulphur bacteria are not far away. Even if, for example, organic sulphur compounds used for vulcanizing rubber are not accountable for acid formation in rubber hose, it cannot readily be assumed that other sulphur compounds used as specific additives in petroleum hydrocarbon oil media are equally neutral with respect to the bacteria. To the writer's observation, the environment presented by the familiar humidity cabinet technique in the evaluation of rust inhibiting compounds is almost ideal for the functioning of one or another species of sulphur bacteria, if they are present.

To what extent, under field conditions, environmental factors favor the contribution of these organisms to corrosion is a subject which it seems to the writer is entirely legitimate material for research. Methods are available, and optimum conditions known, for cultivation of many of the organisms for laboratory study, as are methods for their detection and isolation, as, for instance, by the use of nutrient peptone media containing lead sulphite (13). Of extreme interest in this connection is the finding (14) that strips of sheet steel in tubes containing nutrient broth, previously heated in boiling water bath to expel air, have a remarkably stimulating effect on growth promoting properties of the media for anaerobic bacteria.

SUMMARY

In this paper the phenomenon of bacterial deterioration of cutting oil emulsions is used as an illustrative link to indicate why and how sulphur reducing bacteria may well be regarded as a subject for study by the industrial microbiologist. The literature is briefly surveyed to emphasize the intersection between the lines of investigation familiar to the iron and steel technologist and the lines normally regarded as primarily biological and to underline the research trends and possibilities in the field of corrosion of iron and steel in the area where it overlaps existing knowledge of chemoautotrophic microorganisms.

DISCUSSION

PRESENTED BY

C. E. PRITCHARD, Lubrication Engineer, Republic Steel Corporation, Cleveland, Ohio

E. S. CARMICHAEL, Socony-Vacuum Oil Company, New York, New York

ARBA H. THOMAS, Chief Chemist, Research Laboratories, American Rolling Mill Company, Middletown, Ohio

C. E. Pritchard: This subject of bacterial deterioration is one which has mystified us all for quite some time. All too little is known of the so-called functional operation that takes place during the deterioration of soluble oil emulsions as we see it in field operating practice.

There is one possible explanation that has not been too well covered to date, which might be given at this time and which draws a parallel with the picture given by the biochemist. In explaining the purification cycle of mother nature concerning stream pollution, a stream purifies itself principally by means of its own bacteria. The aerobic bacterium which is normally found in the upper levels of a stream cannot live without oxygen, and feeds upon the suspended and dissolved matter, whereas the anaerobic bacterium, which cannot live in the presence of oxygen, is generally found at the bottom of a stream and feeds upon the solid matter which tends to settle to the river bed. Whenever the stream has been contaminated or polluted with various forms of waste matter, the above mentioned activity takes place. As the aerobic bacterium feed they tend to multiply, consequently consuming more and more of the available dissolved oxygen in the water. Although the stream generally replenishes its oxygen supply by passing over rocks and falls, the entire rehabilitation program may be destroyed by excess contamination being induced therein. Where this condition is encountered the aerobic bacterium in feeding on the fluid wastes multiply to such an extent that all the dissolved oxygen has been consumed and the anaerobic bacterium comes up to the then oxygen lacking upper levels. As they feed, hydrogen is extracted from the water and sulphur from the waste matter to form hydrogen-sulphide so commonly noted in contaminated and sluggish streams.

Another point of interest is the known lower and upper temperature limits for all forms of aquatic life including bacteria with a range of from 104 to 111.2 F. Thus it may be seen that temperature alone may be considered a dominant factor in either the propagation or destruction of the bacterium necessary for purification of the water.

In drawing an analogy of the bacterial deterioration of soluble oil emulsions with the cycle offered by the stream purification phenomena, it might be stated that experience alone indicates that more trouble has been noted with emulsions in a dormant state, than where they have been continually aerated in an active machine. The tendency toward the development and emissivity of hydrogen-sulphide odors also indicates the presence of sulphur reducing bacterium in the emulsion. On the other hand, we have employed a method of control for years in the nature of sterilization of the emulsion simply by maintaining it at an elevated temperature for a given period of time.

In summarization, it behooves us all to analyze the various contributing factors that cause bacterial deterioration of soluble oil emulsions and to utilize the knowledge of their functional operations as offered by the biochemist in meeting common stream pollution problems. Emphasis on the maintenance of a clean and well aerated system cannot be stressed too strongly.

E. S. Carmichael: Mr. Liberthson's article is of considerable interest since the presence of facultative anaerobic bacteria in soluble cutting oil emulsions occasionally causes operating difficulties in the machining of metals. Aside from the fact that emulsions thus contaminated frequently evolve the obnoxious smelling gas, hydrogen sulphide, mixtures in this condition are generally corrosive to ferrous metals, and, as bacteriological

reactions proceed, become unstable with a resultant separation of the oil and water phases. As pointed out by Mr. Liberthson, aeration, steaming, and the use of germicides are some of the measures which are currently employed in the metal working industries for combating facultative anaerobes.

Reference is made in this paper to corrosion of pipe lines resulting from bacterial action. Considerable original work was carried out in this connection by the Dutch and several interesting papers on this subject were published by Mr. Raymond Hadley in The Oil and Gas Journal and The Petroleum Engineer. A probable explanation of the mechanism of this corrosion may be as follows. Under ordinary circumstances when a pipe line or other ferrous structure is placed underground, particularly in swampy areas where organic matter is present, the structure becomes polarized and protected by a film of hydrogen on the iron. However, if sulphates and the proper strain of anaerobic bacteria are present, the latter, in their metabolic process, reduce the sulphates with the consequent liberation of oxygen. The liberated oxygen destroys the protective hydrogen film thus causing the surface in the vicinity to become anodic. When this condition occurs, the usual processes of galvanic action proceed and severe corrosion results. In general, protection against this action can be effected cathodically by employing relatively high current densities and/or through the use of an adequate coating on the pipe which will prevent access of moisture thereto.

Arba H. Thomas: Investigation of the bacterial deterioration of cutting oil emulsions by organisms of the sulphate-reducing type, and the remedies prescribed for overcoming this deterioration, should be of special interest to producers and users of these materials.

The observation that the environment of the familiar humidity cabinet test, used for evaluating rust-inhibiting compounds, may well be worth further investigation. Conditions encountered in this test conceivably could be ideal for the rapid growth of certain types of organisms, as many species will withstand relatively high temperatures.

Since the speaker has made few specific references to factual data concerning the effect of sulphate-reducing and iron-consuming bacteria in the corrosion of iron and steel, it may be of interest to cite some specific cases.

Hadley (15), (16), (17), has made comprehensive studies on the effect of certain types of sulphate-reducing bacteria in corrosion of underground pipe lines. It is understood that by the proper microbiological study of soils, fairly reliable information can be obtained on the anticipated degree of corrosivity. In some cases this has been used as a guide in determining whether or not additional protection should be given pipe lines buried in soil "hot spots," as they are called. Von Wolzogen Kuhr (18), (19) was one of the first to propound the biochemical theory of corrosion relating to soil corrosion of metals. He accumulated considerable data in his studies of the wet, organic lowland soils of the Netherlands.

Another case (20) of the actual corrosion of metals by either the iron-consuming or sulphate-reducing organisms or both, was encountered in a steel water line that carried a low flow of water during most of the year. Based on the usual mineral analysis, pH and the Langlier index, it was indicated that this water was noncorrosive. Yet, two years after installation this pipe line began to perforate on the inside bottom beneath large tubercles.

Bacteriological examination of the tubercles revealed the presence of iron-consuming bacteria of the crenothrix and leptothrix types. Because of the slow flow it was concluded that the organisms formed colonies or "nests" on the bottom of the pipe, which resulted in formation of oxygen concentration cells conducive to pitting. Putrefaction products probably played an accelerating role in the pitting attack.

After this failure laboratory studies were made of noncorrosive well water in the Miami Valley in Ohio. This study showed that certain organisms were highly susceptible to dissolved oxygen. It was also noted that when the dissolved oxygen was reduced to 0.3 ppm, there was an accumulation of voluminous, fluffy, rust-appearing corrosion products, definitely more pronounced than at higher oxygen concentrations (9.0 ppm). Bacteriological examination revealed crenothrix, spirophyllum, and leptothrix, while an agar culture showed the capsulated forms of cocco-bacilli. All three types flourished at the low oxygen concentration (0.3 ppm) while at 9.0 ppm oxygen crenothrix was the chief organism present. Introduction of chlorine in amounts sufficient to give a residual content between 0.5 and 1.0 ppm brought rapid removal of the heavy deposit samples immersed in the low oxygen (0.3 ppm) water.

There are many cases on record of where chlorination proved decidedly efficient in the destruction of the water organisms conducive to severe corrosion. To be entirely sure of the corrosivity of water, a bacteriological examination should supplement the usual chemical analysis. If bacteriological examination reveals the presence of organisms that contribute to corrosion, some inhibitive treatment such as chlorine should be used to insure utmost service.

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ROD MILLS AND ROD MILL ROLL DESIGN

. . . . with this review of the development and design of rod mills, Mr. Beynon adds a fifth chapter to his previous comprehensive papers which dealt with bar mills, blooming and billet mills, structural mills, and rail mills . . .

By ROSS E. BEYNON, Superintendent, Roll Shop, South Works, Carnegie-Illinois Steel Corporation, Chicago, Illinois

▲ THE making of rods can be traced back to before the Christian era. The biblical Tubal Cain, said to be seven generations from Adam, was a skilled artificer of brass and iron. Archaeologists have found specimens of wire in many ancient ruins. Gold wire is mentioned as being used in the robes of the high priests of the pagan temples. A specimen of iron wire made in 800 B.C. was found in the ruins of Nineveh.

The earliest known practice used in the manufacture of iron wire was to hammer the iron into plates and then chisel strips from the plates, the strips then being hammered into wire. This was before the invention of the draw plate. The draw plate was brought into use in the sixteenth century according to some authorities. There is some reason to believe, though, that draw plates were known in the 12th century, as Theophiles, or Lugervs, a monk said to have lived in that time, mentions draw plates in his writings. After the draw plates were put into use, cut strips from the plates were first hammered and then drawn.

The first mills to roll a product which was converted into wire were two-high with plain rolls. The flat product rolled in these mills was slit into strips by hand, hammered and then drawn into wire. A further development of this type mill had an additional two-high stand of rolls a short distance away, where the flat plates produced on the first stand were cut into strips by sharp collars on the rolls of the second stand. These mills were the original rod mills. These strips were also hammered and drawn. Many of the mills were run by water wheels. Such mills are known to have been in operation as early as 1683. In the USA, this type was built according to some authorities about 1750. Drawing 1 illustrates a mill of the same general type as the one first installed in this country.

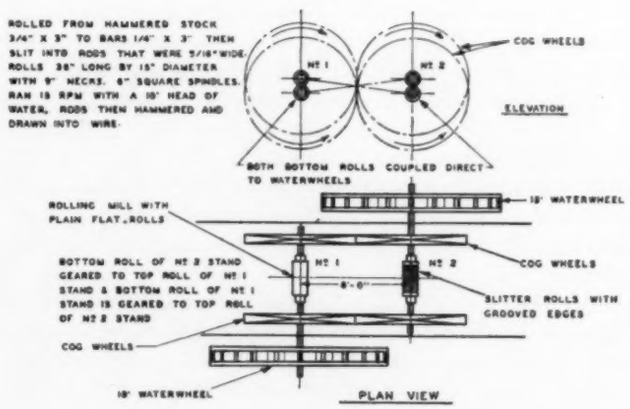
Christopher Polhem a noted Swedish mill operator installed some of these rolling, slitting mills in Sweden in 1697 after a trip to England and the continent where he studied the rolling technique. He is also said to have rolled bars and shaped profiles long before Cort patented his bar mill. Among other innovations in rolling mills he invented a four-high mill in the early 1700's. The mill had back-up rolls supporting smaller work rolls. Polhem and others who preceded Cort in the bar mill work did not make a great deal of headway with their mills, and Cort is rightfully given the credit for his improvements on the work of his predecessors and for making a commercial success of the rolling of bar iron.

The Frenchman Fleur in 1778 introduced some innovations in the rolling of rods. He hammered bars of iron to an oval shape and in four stands of rolls rolled the bars to 0.354 in. round wire rods. The first three passes were oval to oval sections and in all probability he used some system of guides to hold the ovals up in the passes. Although this was before Cort's time, grooved rolls were used.

The inventions of Cort and others in rolling mills with grooved rolls started a new era in rod rolling. The first rod rolling mills were two-high and the rounds were at first made by the hand round rolling method. The product was of necessity in rather short lengths probably less than 20 feet, and of a minimum size of around ½ in. in diameter. This was as small as could be readily handled by the hand round method. There are known instances, however, where ⅜ in. rounds have been rolled by hand.

These early type mills usually consisted of two to three stands of two-high rolls in line, the first stand fitted with gothic roughing passes and the second stand with the round grooves. The third stand, when the mill

Drawing 1 — This early rolling mill, built in 1751 for Peter Oliver, Middlesboro, Massachusetts, was run by a water wheel.


ROLLED FROM HAMMERED STOCK 3/4" X 3" TO BARS 1/4" X 3" THEN SLIT INTO RODS THAT WERE 5/16" WIDE. ROLLS 38" LONG BY 15" DIAMETER WITH 9" NECKS. 6" SQUARE SPINDLES. RAN 15 RPM WITH A 10' HEAD OF WATER. RODS THEN HAMMERED AND DRAWN INTO WIRE.
COG WHEELS
NO 1
NO 2
ELEVATION
BOTH BOTTOM ROLLS COUPLED DIRECT TO WATERWHEELS
ROLLING MILL WITH PLAIN FLAT ROLLS
18' WATERWHEEL
BOTTOM ROLL OF NO 2 STAND GEARED TO TOP ROLL OF NO 1 STAND & BOTTOM ROLL OF NO 1 STAND IS GEARED TO TOP ROLL OF NO 2 STAND
8'-0"
SLITTER ROLLS WITH GROOVED EDGES
COG WHEELS
18' WATERWHEEL
PLAN VIEW

Presented before AISE Annual Convention, Cleveland, Ohio, October 4, 1946.

had one, was usually a two-high set with plain rolls, and used for finishing and polishing flats. Drawing 2 shows a two-stand mill.

The invention of guide rolling for rounds where the bars were held in the passes by guides, was a big step forward. This permitted the rolling of smaller sizes and greater lengths. The date at which guide rounds were first rolled is unknown but must have been around 1800. Drawing 3 illustrates the hand round method and the guide round method.

When the three-high mills were developed it became possible to roll still smaller rounds. It is not definitely known just when the three-high mill for bars or rods was developed, although its use was known before John Fritz developed the first three-high mill for rails in 1857. It is certain that three-high mills were used long before Fritz's mill for the smaller sizes. De Beaumont and Dufrenoy, who visited England about 1819, noted three-high mills for small sizes, so it is probable that they were in use about 1800. At first the rounds were rolled without looping. Rounds ¼ in. in size were rolled from 1 to 1¼ in. billets of a weight of 10 to 12 pounds. Sometime later, about 1860, it was discovered in Germany or Belgium that the intermediate and finishing passes were so light and easily bent that they could be repeated and thus finished several degrees hotter, and that looping permitted longer lengths to be rolled. The longer lengths were then coiled instead of being run out on a hot bed. The bars were run out on the floor in ribbon fashion and caught with tongs and inserted into the reel where they were reeled up with a crank. The coiler was operated by a boy.

One of the earliest examples of the early type rod mill in this country was the one built in Massachusetts by the Fall River Iron Company in 1839. This mill was rebuilt several times. It consisted of three stands of rolls, two three-high and one two-high, and could be driven by either a water wheel or an engine. The original mill produced ¼ in. rods at the rate of three tons per turn. The billet was 1¼ in. square and of about 10 pounds weight. The mill as rebuilt in 1843 used 25 pound billets, and rods were rolled as small as 3/16 in. The tonnage also increased to five to eight tons per day. Mills of the general design of the Fall River mill were built in many places. One of these mills is illustrated in Drawing 4. This mill was known as the Quinsigamond mill and was built in Worchester, Massachusetts by Ichabod and Charles Washburn.

A typical mill somewhat advanced from the early three-stand mill was the four-stand 8, 9, or 10 in. rod mill. These mills used a small billet, and in most cases did not do any repeating. The leader and finishing rolls, were two-high. Such a mill is shown in Drawing 5, Figure 1. This type rod mill was known as a Belgian type mill, because the mill originated in Belgium.

Belgian roll trains consisted of four or more stands in line. The standard in England for some years was a five-stand mill. In these trains where the nominal size was 8 in. diameter, it was the practice to make the three-high roughing an inch larger in diameter for strength. The speed of the train was regulated by the ability of the tongsmen working at the roughing stand to catch the bars as they came out of the passes, and the roughing stand being of the largest diameter had the greatest peripheral speed. The maximum speed of these trains in England and Germany was about 400 rpm or about 900 feet per minute. In France, the mills were run faster as the French workmen were quicker.

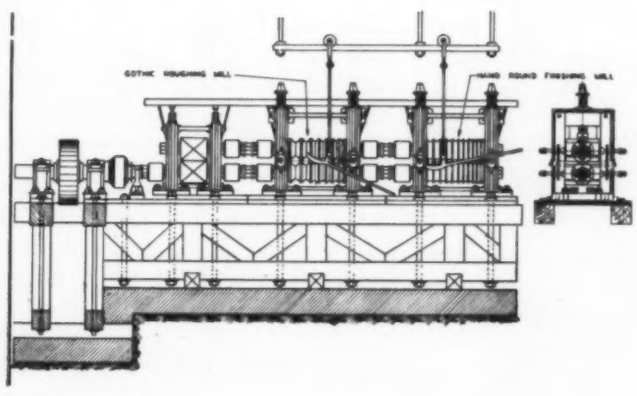
After the practice of looping was inaugurated, the mills were provided with more stands, but the roughing was still operated as a forth and back stand, the finishing passes being looped. Mills of this type had as many as seven stands in line. A mill of this design is shown on Drawing 5, Figure 2 and could use a billet as large as 2 × 2 in. and consequently roll longer lengths and greater tonnages.

The next step in the direction of longer lengths and greater tonnage was a development which is credited to Belgian and German mill operators.

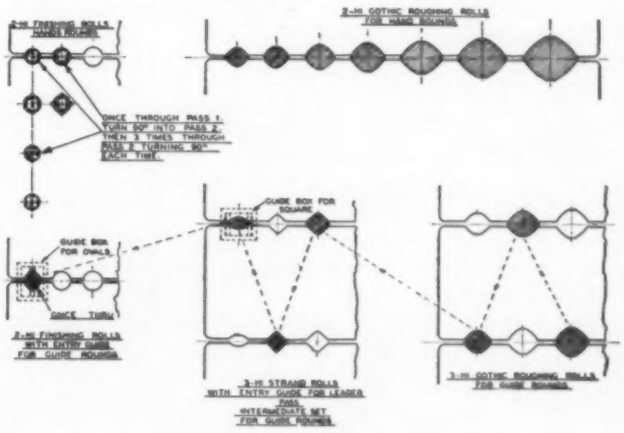
In Germany, the first Belgian type rod mill is said to have been built in 1817. In 1838, Friedrich Thomee placed a separate roughing roll stand in front of the finishing roll stands, running the roughing stand at a suitable speed for the best work conditions for the roughers, using a larger billet and reducing it to a suitable size for looping in the finishing train, and speeding up the finishing stands so that it was possible to roll one to one and one half tons of rods per hour, which was considerably better than had been done. See Drawing 5, Figure 3.

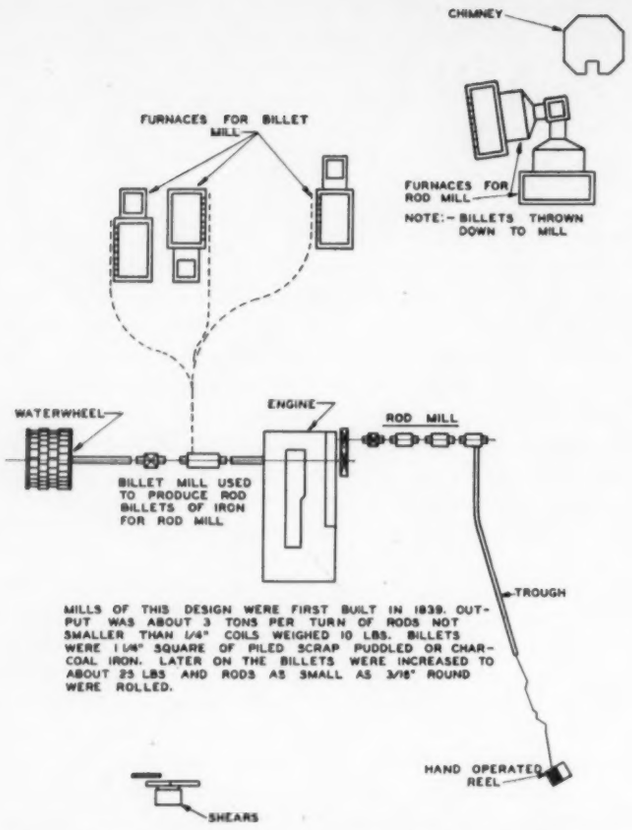
Drawing 6 illustrates a mill of this type installed in

Drawing 2 — Early two-stand English bar mill of 1819.



Drawing 3 — The hand round method was first superseded by the guide round method in about 1800.


2-HI FINISHING ROLLS HAND ROUNDS
2-HI GOTHIC ROUGHING ROLLS FOR HAND ROUNDS
ONCE THROUGH PASS 1 TURN 90° INTO PASS 2 THEN 3 TIMES THROUGH PASS 2 TURNING 90° EACH TIME
GUIDE BOX FOR SQUARE
GUIDE BOX FOR OVALS
ONCE THRU
2-HI FINISHING ROLLS WITH ENTRY GUIDE FOR GUIDE ROUNDS
3-HI STRAND ROLLS WITH ENTRY GUIDE FOR LEADER PASS INTERMEDIATE SET FOR GUIDE ROUNDS
3-HI GOTHIC ROUGHING ROLLS FOR GUIDE ROUNDS


CHIMNEY
FURNACES FOR BILLET MILL
FURNACES FOR ROD MILL
NOTE:- BILLETS THROWN DOWN TO MILL
WATERWHEEL
ENGINE
ROD MILL
BILLET MILL USED TO PRODUCE ROD BILLETS OF IRON FOR ROD MILL
TROUGH
MILLS OF THIS DESIGN WERE FIRST BUILT IN 1839. OUTPUT WAS ABOUT 3 TONS PER TURN OF RODS NOT SMALLER THAN 1/4" COILS WEIGHED 10 LBS. BILLETS WERE 1 1/4" SQUARE OF PILED SCRAP PUDDLED OR CHARCOAL IRON. LATER ON THE BILLETS WERE INCREASED TO ABOUT 25 LBS AND RODS AS SMALL AS 3/16" ROUND WERE ROLLED.
HAND OPERATED REEL
SHEARS

Drawing 4 — The Quinsigamond rod mill took its name from the lake which first furnished its water power.

Massachusetts by the Washburn and Moen Company in 1876. This is said to be one of the first of this type installed in this country although these mills had been in use in Europe for years. The mill used billets as large as 4 × 4 in. and in the 12 in. roughing stand rolled them to about 1⅛ in. square. In the 8 in. finishing mill, the 1⅛ in. size was reduced to rods as small as No. 6. The tonnage was from two to four tons per hour. Note that there are four loops of the same rod in the second and third stand. This is said to be the first instance of four loops of the same rod between two stands. Another example of the Belgian type mill is that of the Cooper Hewitt Company of New Jersey, one of the early mills. It consisted of a one-stand, three-high, 12 in. roughing and a six-stand, 10 in. looping mill. Drawing 7 illustrates this mill.

The continuous rolling of rods was first done successfully in 1862 by George Bedson of England. He was not, however, the original patentee of continuous mills as several patents preceded Mr. Bedson's.

The patents of John Hazeldine of England in 1798 for continuous mills, also those of J. E. Serrel of this country, who patented and constructed a continuous mill which rolled lead pipe on a mandrel in the years 1842 to 1845 were taken out by two of the pioneers in this field. Henry B. Comer secured a patent in 1859 for a mill described as continuous. A. S. While who built several three-stand continuous roughing mills, also secured a patent in 1861.

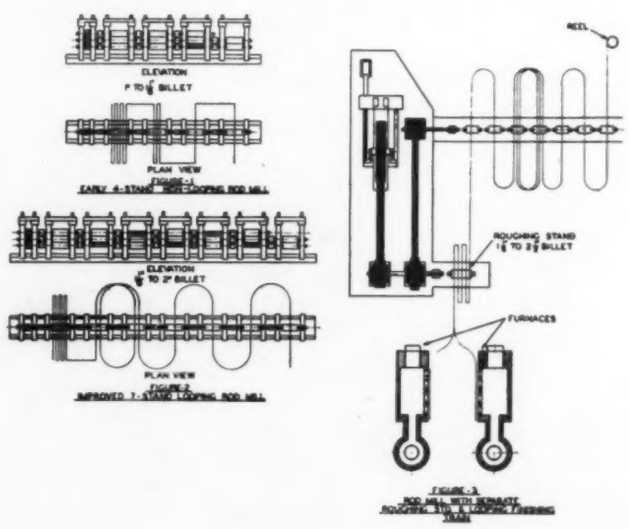
The Henry B. Comer mill patent of 1859 described a mill said to be continuous but was of a looping type. Drawing 8 illustrates the mill. In each roll housing were placed two pairs of rolls, (Figure 1), each pair rolling in opposite directions. A guide conducted the bars from the top pair to the bottom pair which was suitably speeded up to take care of the reduction and the elongation of the bar. The bar was then conducted to another four-high set in another housing on the same bed plate. The bar was repeated through a twist guide to this second roll stand and this stand was speeded up to take care of the elongation from the first set. A shaft under the roll housings, with suitable gears attached, was connected to gearing between these two roll stands and this gearing suitably speeded the various pairs of rolls. A complete rod mill of this type was to consist of four mills in line and in addition one pair of finishing rolls. As far as is known there were no installations of the Comer four-high mill, but at Johnstown, Pennsylvania, the Cambria Iron Company put in a rod mill which had some of these features. The Johnstown mill, built in 1881, had a number of sets of two-high roll stands with pinions, each set being connected to a geared shaft running under the train. The second of each two-high set of rolls were increased in diameter over the first set in order to minimize the loop formed between the two stands. Each additional group of rolls was run faster than the preceding one to take care of rod elongation between groups. Drawing 9 illustrates the mill and passes.

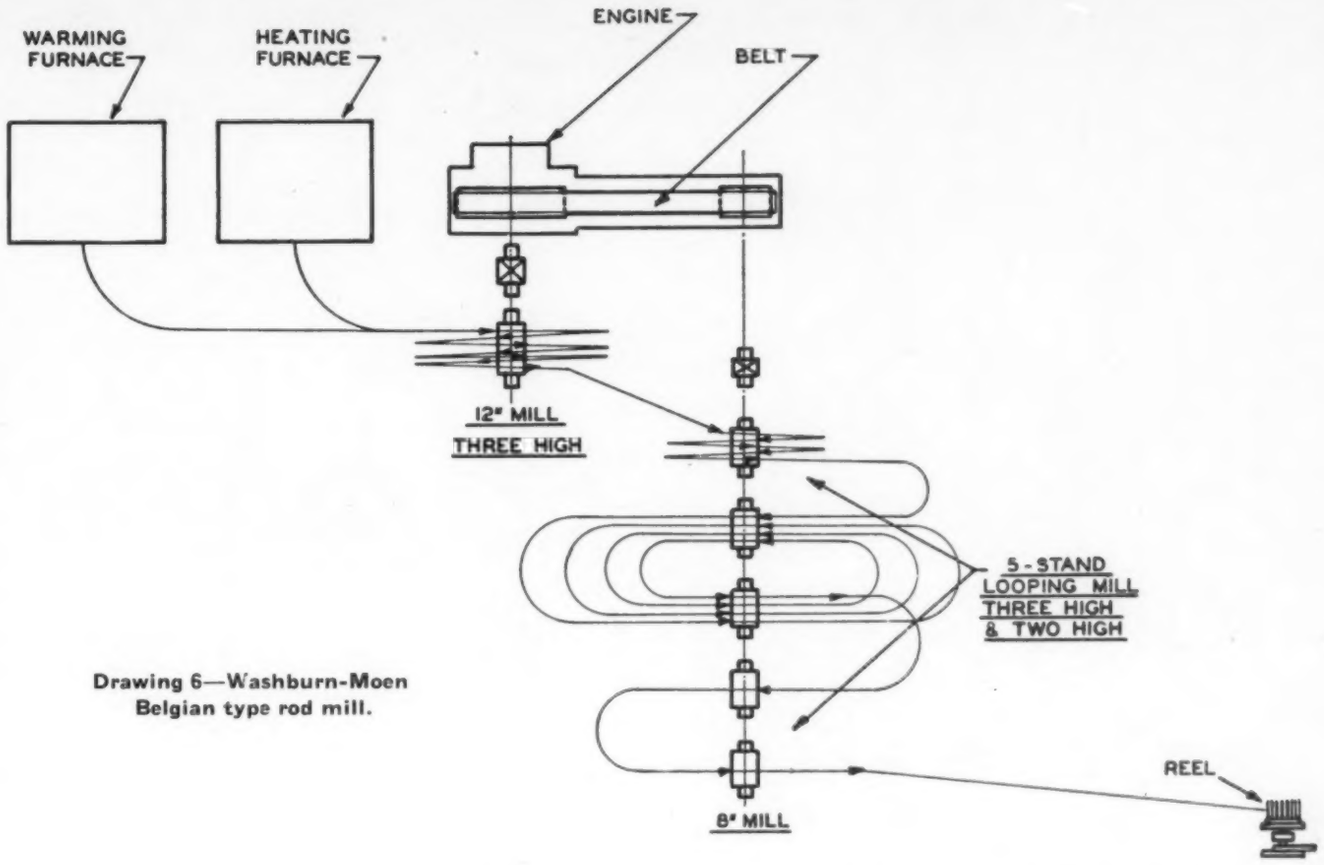
One engine geared to the shaft under the roll stands drove the first three-high 9 in. roughing stand and two of the eight two-high stands. The other stands of the mill were driven by another engine. Each succeeding group of rolls was driven at an increasing speed, the first set of two-high rolls of each group being 8 in. in diameter, while the second set was 10 in. in diameter. By this design, loops between stands were kept at a minimum.

The mill used either an oval or rectangular billet equivalent in area to a 1⅛ in. square and weighing 100 pounds. The continuous furnace was equipped to take fifteen 22 ft-0 in. billets at a time, and the mill averaged about 30 tons of No. 5 Birmingham wire gage rods per ten hour turn. The passes are shown on the drawing.

Mr. Bedson's mill, as far as is known, is the first one to successfully roll rods continuously. His mill at first

Drawing 5 — Early 4 and 7 stand Belgian rod mills.





Drawing 6—Washburn-Moen Belgian type rod mill.

had a separate and independently driven finishing stand to which the bar was manually looped. This stand was finally taken out and a finishing stand added to the continuous train. See Drawing 10, Figure 1. The roll stands were alternate horizontal and vertical with the diamond passes in the horizontal stands, and the passes for the squares and the finishing round in the vertical stands and the leading oval in the last horizontal stand. In this system there are no twist guides used, since there is no twisting of the bars. The billet used was about $1\frac{1}{16} \times 1\frac{1}{16}$ in. and of 100 pounds weight. The heaviest weight billet used up to that time was rolled in Europe on the Belgian type mill and was about 50 pounds.

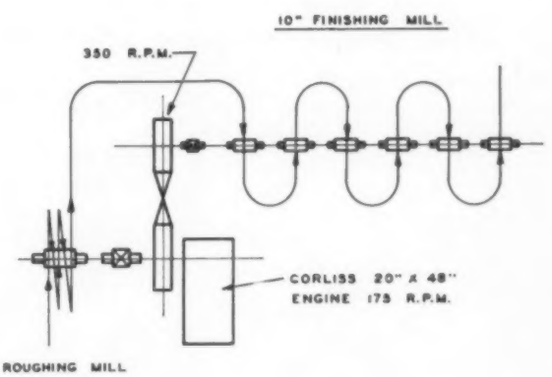
The chief drawback to the Bedson mill was that it would not roll common puddled bar iron. This material would not stand the stretching it received in the continuous stands. The production was telegraph and the best grades of fencing wire, and the billets used were made from special box piles. The inside squares were from the best puddled iron, and the flat pieces on the outside were of the best grade of charcoal iron or several times refined puddled iron.

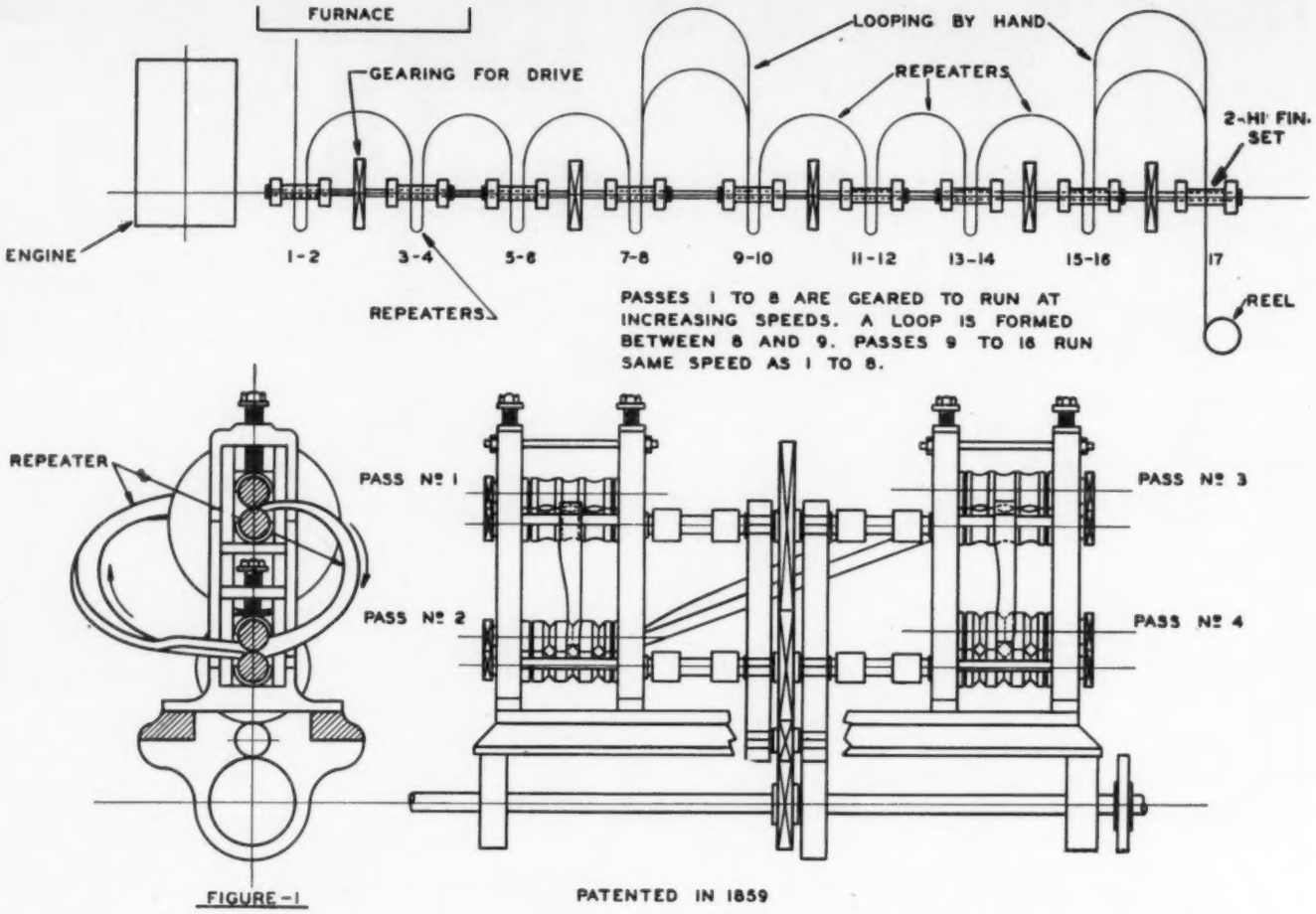
In 1869 a Bedson mill was installed in this country at the works of the Washburn and Moen Company. It was similar in design to the English mill. This mill also had difficulties with iron, but with the advent of bessemer steel it was more successful. The Belgian type mill before mentioned was used for common grades of iron.

The Bedson mill with its alternate horizontal and vertical roll stands was a difficult mill to maintain, and in 1878 Charles H. Morgan of the Washburn and Moen Company designed and built a continuous mill with all horizontal stands, and introduced twist guides on the mill to twist the bars between stands into proper position for rolling. This mill was a success. The design made it possible to roll more than one rod at a time which was not possible on the Bedson mill. See Drawing 11.

Mr. C. H. Morgan also built a combination continuous and Belgian type mill in 1882. This mill is shown in Drawing 12 and had an eight-stand continuous roughing and a four in line finishing mill. It rolled $1\frac{3}{16}$ in. billets, 100 pounds in weight, to $\frac{3}{8}$ in. on the continuous stands, and finished the rod on the four stands

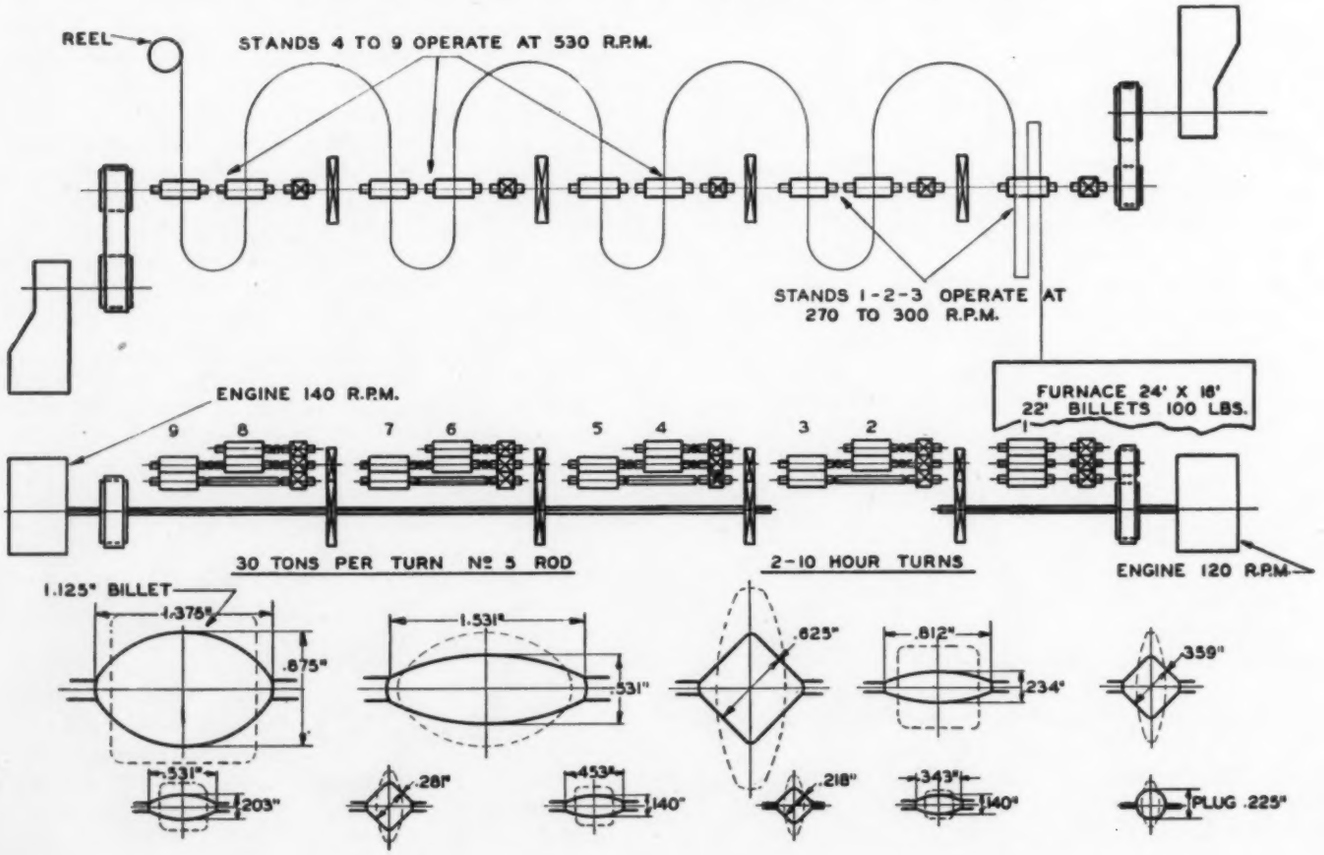
Drawing 7 — This Belgian type rod mill built in 1881 for Cooper-Hewitt and Company, had an average production of 42000 lb of No. 4 rod per turn from 45 to 50 lb $1\frac{1}{2}$ in. square billets.

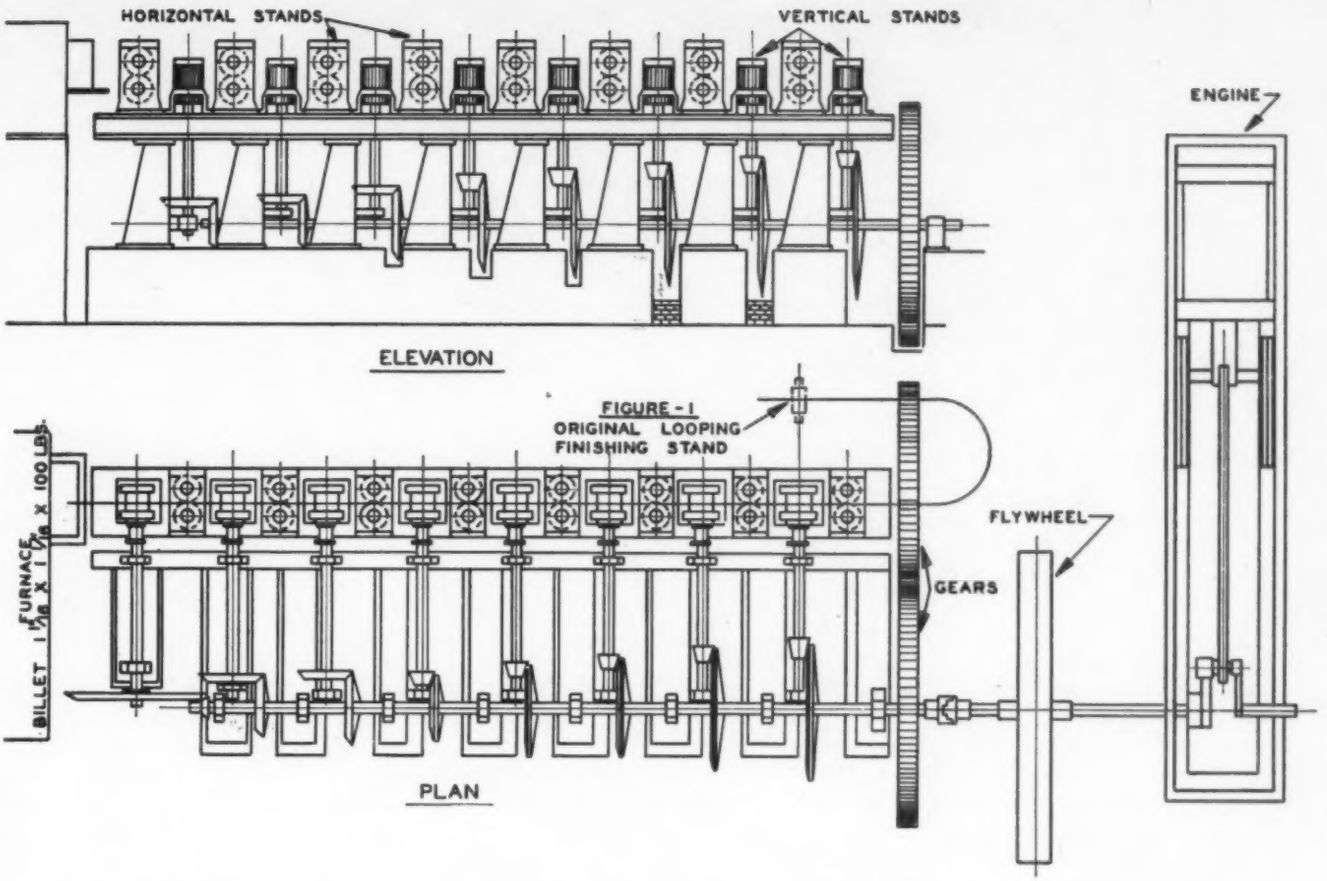




Drawing 8 — The Comer continuous mill was of the looping type.

Drawing 9 — This Cambria Iron Company mill was built in 1881.





Drawing 10 — The Bedson continuous rod mill, patented in 1862, was the first to roll rods continuously.

of the looping mill. This was the first mill of this type ever built.

The next development in rod rolling was the work of William Garrett, superintendent of the Cleveland Rolling Mill Company of Cleveland, Ohio. At the Cleveland Rolling Mill Company prior to 1882, the practice was to cast bessemer steel ingots of 8 to 9 in. size and weighing about 900 pounds, and roll them to about 5 in. square, shear and reheat them, and roll them on an 18 in. three-high mill to 1⅛ in. square. These bars were then cut into pieces of about 35 to 40 pounds weight and heated in the rod mill furnace and rolled into rods.

The early type rod mills of the company are illustrated in Drawing 13, Figures 1, 2, and 3. Figure 1 shows the first rod mill built, a four-stand 9 in. mill and a one-stand 18 in. breakdown mill. This mill was started in 1868 and the design was considered a first class one at that time. Six puddle iron furnaces were used to provide stock. The puddle balls were hammered to about 6 in. square, and charged into the heating furnace shown at the right. The puddle bloom was rolled to 1⅛ in. billets in the 18 in. three-high mill. The 1⅛ in. billets were then cut into pieces of fifteen pounds weight and charged into the furnace shown immediately in front of the 9 in. train and heated and rolled into No. 4 rod (0.238 in.). The puddle iron of this district did not make good rods but the mill was utilized to slit bessemer rail butts and roll the pieces into rods. This mill was changed to five stands of rolls several years later.

The five-stand mill shown in Figure 2 was built and operated first in 1870 and was a leading tonnage producer of its time. It was operated at first without any looping, and beginning with seven tons per turn in 1870 had worked up to eighteen tons per turn in 1881. The mill used a billet of fifteen to twenty-five pounds weight. On the other side of the engine of this mill was an 18 in. three-high roughing stand which was used for rolling bessemer steel rail crops into billets for use on the rod train. These billets were cropped as produced and charged hot into the rod mill furnace.

In 1875, the mill shown in Figure 2 was remodeled into the design shown on Figure 3. The train was split into two parts of three roll stands each as shown, the second half running at a higher rate of speed than the first. About this time the Belgian looping system of rolling rods was introduced into this country, and the tonnage of rods produced was vastly increased. On this mill a night roller by the name of William Woodward set up the finishing rolls with two sets of guide boxes and introduced the rolling of two rods at a time.

This remodeled mill also had the 18 in. breakdown train operated by the right hand rod mill engine. This 18 in. stand was operated for the rolling of rail butts into rod billets. In addition to rolling single rail butts, the mill also used a rail pile which consisted of several rails piled up. They also slit rails to make stock for the rod mill.

The Troy Steel Company and the Cambria Iron Company had the best practice of the times for producing rod billets. In their practice they used a 12 to 14 in. ingot and bloomed the ingot down to about 7 ×

TABLE I

COMPARATIVE TABLE OF STANDARD GAGES

(Thickness in decimals of an inch)

Gage number	Birmingham wire (B.W.G.) also known as Stubs iron wire	American wire or Browne and Sharpe	United States Steel wire formerly Washburn and Moen	Trenton Iron Company	British Imperial standard wire (S.W.G.)	Standard Birmingham sheet and hoop (B.G.)
0000000	.....	.....	0.4900	.....	0.500	.....
000000	.....	0.580000	0.4615	.....	0.464	.....
00000	.....	0.516500	0.4305	0.450	0.432	.....
0000	0.454	0.460000	0.3938	0.400	0.400	.....
000	0.425	0.409642	0.3625	0.360	0.372	0.5000
00	0.380	0.364796	0.3310	0.330	0.348	0.4452
0	0.340	0.324861	0.3065	0.305	0.324	0.3964
1	0.300	0.289297	0.2830	0.285	0.300	0.3532
2	0.284	0.257627	0.2625	0.265	0.276	0.3147
3	0.259	0.229423	0.2437	0.245	0.252	0.2804
4	0.238	0.204307	0.2253	0.225	0.232	0.2500
5	0.220	0.181940	0.2070	0.205	0.212	0.2225
6	0.203	0.162023	0.1920	0.190	0.192	0.1981
7	0.180	0.144285	0.1770	0.175	0.176	0.1764
8	0.165	0.128490	0.1620	0.160	0.160	0.1570
9	0.148	0.114423	0.1483	0.145	0.144	0.1398

7 in., after which it was reheated and rolled to about 1⅛ in., then cut to lengths weighing about thirty-five to forty pounds, and the pieces reheated and rolled into rod.

These practices and that of the Cleveland Rolling Mill Company were costly and the rod mills at the best only averaged about twenty tons per 24 hours.

Mr. Garrett patented and built a new and radically changed rod mill in 1882. To provide billets for this rod mill, a new two-high reversing blooming mill was built and used to roll 14 in. ingots weighing 3400 pounds into 4 × 4 in. billets with one heating.

The finishing mill consisted of an 18 in. three-stand, three-high roughing train, one stand of 12 in. two-high, and eight stands of 9 in. rolls arranged in two trains of four roll stands apiece and arranged for looping. Drawing 14, Figure 1, illustrates the mill. Four inch billets were used and rolled in 18 passes into No. 4 to No. 6 rods. Three months after this mill was installed, it was producing 72 tons of rods per 24 hours or twice the best previous rod tonnage and, in addition, at a saving of $7 per ton over the old method.

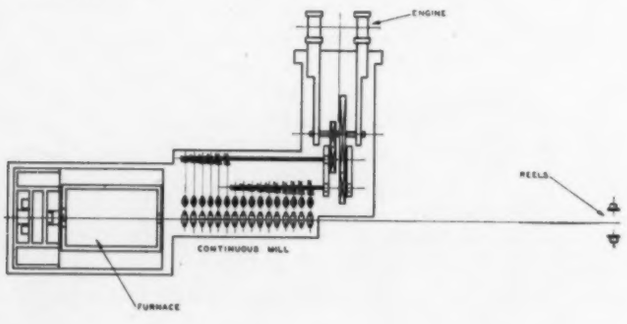
In this mill the roughing stand could roll the short billets of 100 to 140 pounds weight faster than the finishing train could take them away in a single strand, but by setting up guides on several grooves of the finishing mill, more than one rod could be finished at the same time, and it was not long before three rods were run through the finishing stand at once.

In 1886 a new and improved Garrett mill was built in Cleveland at the works of the American Wire Company based on Mr. Garrett's 1885 patent. Figure 2 of Drawing 14 shows this mill. This mill had two 18 in. stands, three 12 in. stands, and the finishing train of two 9 in. trains of four roll stands apiece.

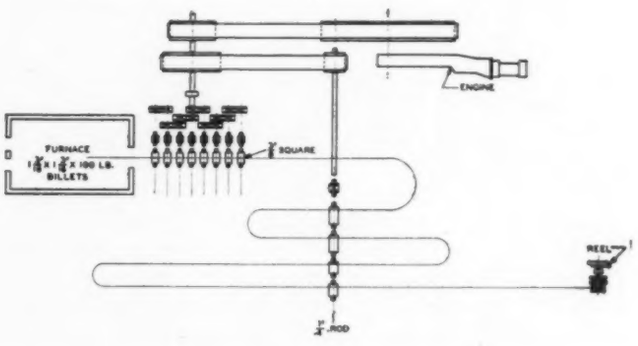
Drawing 15 shows a Garrett type rod mill built at Rankin, Pennsylvania. The original mill was installed in 1885. It was rebuilt and the drawing shows the rebuilt mill. This was a leading tonnage producing mill of its time. The mill rolled 586,170 pounds or slightly over 293 net tons of rod on January 6, 1902.

Drawing 16 shows a Garrett type rod mill built about 1902. In this design, a 9 in. ingot of about 1000 pounds weight is heated and rolled into a 4 × 4 in. billet on a 24 in. three-high mill in nine passes. After being reduced to the 4 × 4 in. size it was cropped and went forward to a four-stand continuous mill where it was reduced to a 1¾ in. square. The bars then went to a ten-stand continuous mill passing through a 32-foot furnace just

Drawing 11 — The first continuous rod mill with all horizontal rolls was built by the Washburn-Moen Company.



Drawing 12 — Combination continuous Belgian type rod mill.

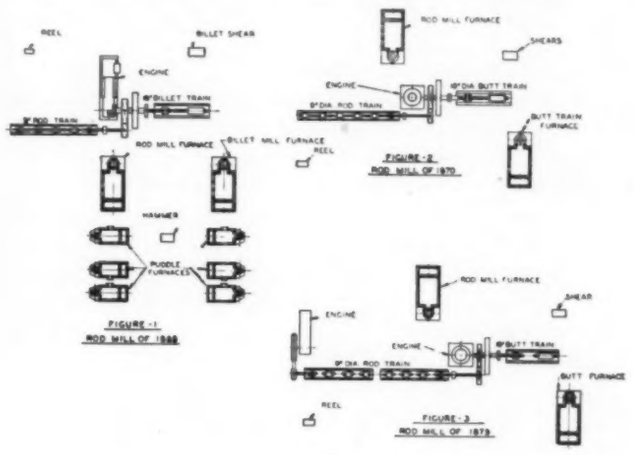


before entering the continuous mill. The piece was reduced to ¼ in. square in this mill, and the next mill is a four-stand looping mill where the bar was finally reduced to a No. 5 rod.

The Garrett Mills from their inception outdistanced all other types of rod mills. They were built all over the country and rolled by far the greatest tonnage of rods. In the later Garrett designs, a semi-continuous roughing was used in place of the three-high roughing. Drawing 17 shows one installed in 1895 and still going strong. This mill some years later had a 10 in. bar mill added on after the roughing line, for the semi-continuous roughing had ample capacity for the finishing mills.

The Cleveland Rolling Mill's night roller, William Woodward, inaugurated the rolling of more than one rod through the finishing rolls at the same time. Though it was some time before this practice became common it gradually came into use.

In Garrett's mills, this multiple rolling reached its peak. It was not uncommon after the continuous

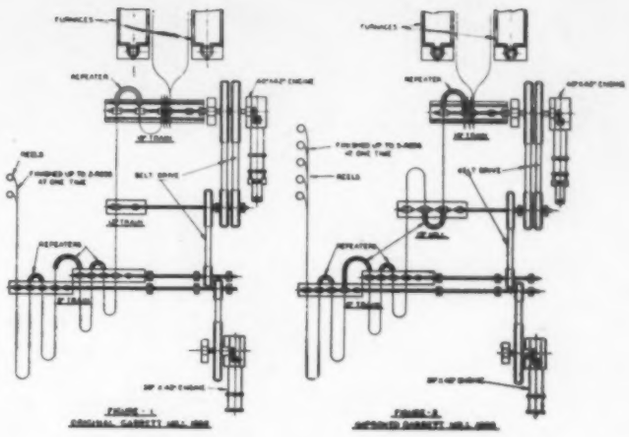


Drawing 13 — Early rod mills of the Cleveland Rolling Mill Company.

roughing was added to the mill to have as many as seven strands of rod going through the finishing mill at one time. How multiple rolling is accomplished may be hard to understand for the layman but it is simple enough.

Drawing 18 represents the Garrett mill built in 1888 in Joliet, Illinois, and a very good tonnage producer of its time.

Drawing 19 shows some figures which illustrate how the rolling of more than one rod at a time is accomplished on the mill shown sketched in Drawing 18. The mill had a hand roughing in which six passes were given. It took 18.7 seconds to work the 4 in. billet down in the roughing stand to the point where it was entered in the sixth pass where it went around a repeater to the second roughing stand. As soon as the bar was well entered in the sixth pass, the rougher was in a position to catch the second billet being delivered from pass one. Figure 1 shows the position of bar No. 1 at this time. Figure 2 shows the position in the mill of bar No. 1 18.7 seconds later as bar No. 2 is in the same position as bar No. 1 was. Figure 3 shows the position of bars No. 1, 2, and 3 as the cycle of operations continued. Owing to the roll



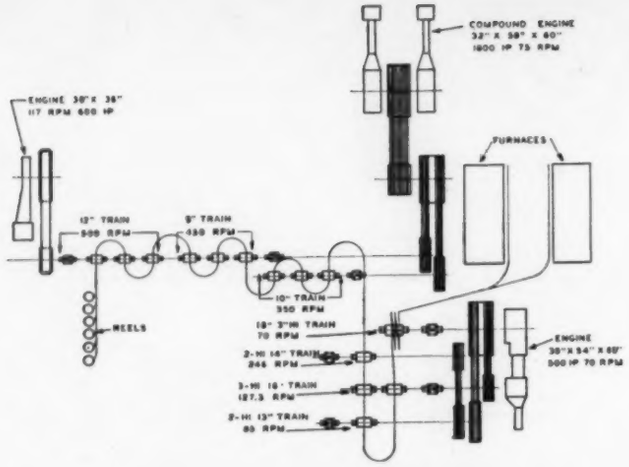
Drawing 14 — Garrett rod mills of 1882 and 1886.

speeds not being faster for each successive pass, a loop forms between passes. This loop gradually increases in length until the bar is through the rolls. As it takes 98.63 seconds for one bar to pass through the mill while it only takes 18.7 seconds between bars at the roughing stand, more than one bar can be rolled at a time by providing extra grooves in each set of rolls in the intermediate and finishing stands of the mill. Figures 4 and 5 show how the various successive bars progress through the mill until three bars are in the finishing stand at once.

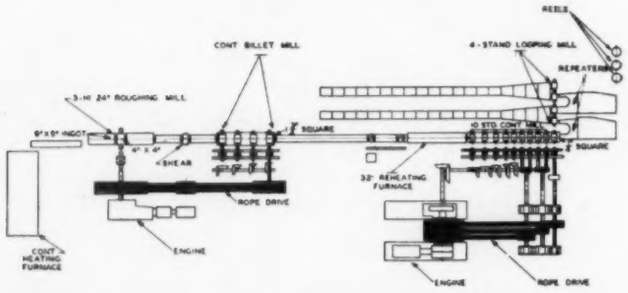
Still faster operation in the first roughing stand which is possible with expert tongsmen permits the rolling of four and five rods at a time. This mill was remodeled in after years. Continuous roughing was installed to take the place of the hand roughing, an additional train known as rod mill No. 2 was built and still later a continuous mill was added to roll rods and cotton tie. See Drawing 20.

Further improvements of the continuous mill were patented by F. H. Daniels in 1883 to 1887. One of these patent mills is illustrated on Drawing 21. The mill was designed to use 4 in. billets, 200 pounds in weight, and rolled the billet to 1⅛ in. square in the ten-stand roughing mill and then finished the rods in separate finishing mills. These mills were intended to meet the competition offered by the Garrett mills. A number of mills were erected in accordance with these patents.

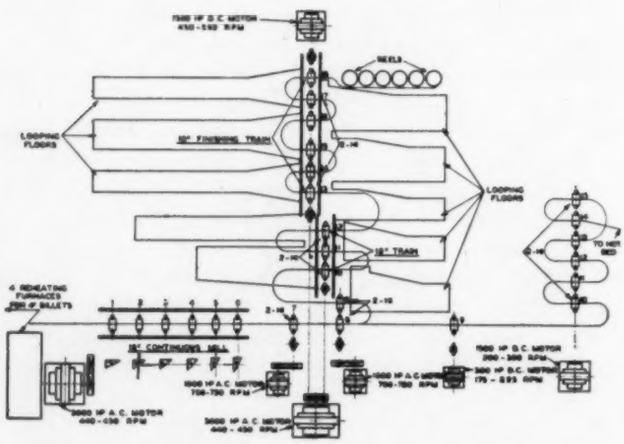
One of the mills Washburn-Moen built on the continuous and looping principle was erected at Waukegan, Illinois about 1891. This is illustrated as it was a few years ago. See Drawing 22. Four furnaces serve the mill. Three of the furnaces were for 3⅞ in. by 212 pound billets and one furnace was capable of handling 3⅞ in. by 300 pound billets. The eight-stand roughing is continuous after the first pass. Two lines of passes are kept open in the mill. Following this roughing mill is the No. 1 rod mill, a continuous rod mill of twelve stands of rolls. The mill also has a series of roll stands after the Boecker design, where the oval entering the square is twisted to the proper position for the square and the stands are close together. The square entering the oval is looped around repeaters. Number 3 mill, a Garrett mill removed from Beaver Falls, Pennsylvania, is of the looping type, copper rods as well as steel being



Drawing 15 — This Garrett type rod mill at Rankin, Pennsylvania, rebuilt in 1901, was a leading tonnage producer of its time.



Drawing 16 — This special type Garrett rod mill was built about 1902 for the Monessen Iron Works.

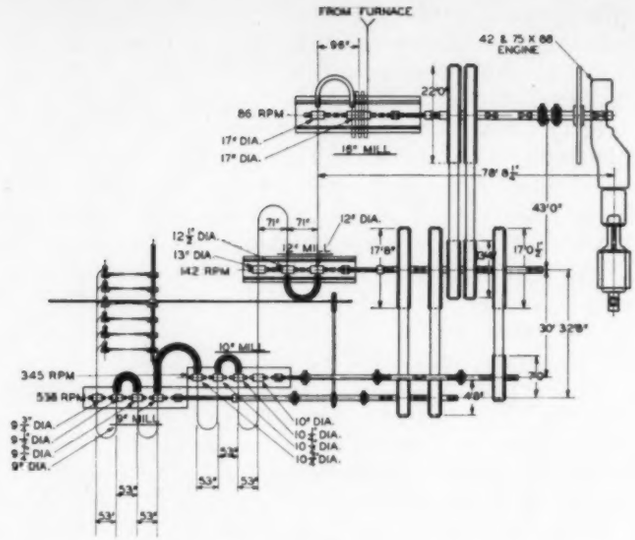


Drawing 17 — This Garrett type rod mill and 10 in. merchant mill is still in operation.

rolled on the mill. The entire mill was capable of about 340 tons per eight hour turn.

Among the English inventors who made rod mill history was John Bleckly of Warrington who perfected a four-high roll stand for use in rod mills. This is illustrated on Drawing 23, Figure 1. A rod train could consist of a series of these roll stands. The feature of the stand is the repeater which received the bar from the two top rolls and conducted the bar to the bottom set.

Another innovation was the Boecker Mill, shown in



Drawing 18 — Garrett mill built in 1888 in Joliet, Illinois.

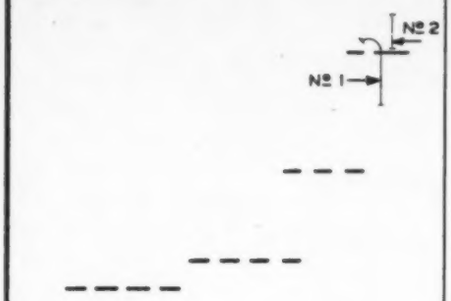
Figure 2, a German invention. This mill consisted of two-high tandem sets of rolls both running in the same direction and suitably speeded for the elongation between stands. The first set rolled an oval which was twisted between the two sets to enter the square in the second set. The square was then looped to the second set of rolls which were running in the reverse direction to the first set. A number of these sets in line constituted a train. Usually a repeater was used to loop the square. This type mill became very popular due to the reduction in hand labor.

When the practice of repeating bars from one pass to another came into use, tongsmen did the work. Many attempts were made to loop the bars mechanically, one of which was a repeater developed by Bevis, but it remained for an American mill man to successfully solve the problem. William McCallip, who was superintendent of a small bar mill at Columbus, Ohio, had been experimenting with automatic looping and introduced the first really successful repeater and patented it in 1877. Others who made improvements on the repeater were T. J. Tallman who made some improvements, and W. T. Thompson and John Walker of Cleveland who put two repeating troughs in one unit.

Repeaters were soon adopted by a great many mills and were responsible for cutting costs and increasing tonnages. The square entering the oval, because of its shape, was easily repeated, but the oval entering the square was another matter. An oval will not go around a repeater in the flat position in which it comes out of the rolls. It is necessary to twist the oval to a vertical position to go around the repeater, or it will jump out before the turn is completed. Although the oval is repeated successfully in many mills, some mill operators still use tongsmen to repeat oval to square.

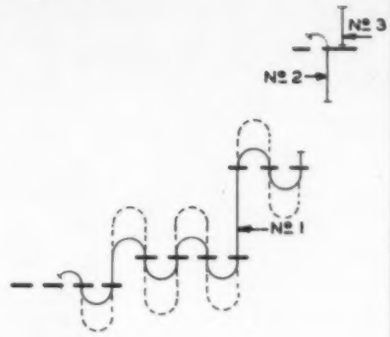
Drawing 24, Figure 1 illustrates a Garrett rod mill repeater for square to oval with space for five rods. Repeaters for three-high roll stands are said to have been first used by the Austrian roller Herman Mosaner. Another repeater was that of Quast who twisted the bar in the repeater for proper entrance in the three-high stand. Figure 2 shows the three-high mill repeater.

FIGURE – 1



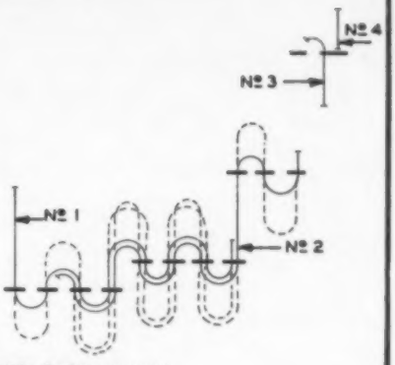
ONE BAR IN MILL

FIGURE – 2



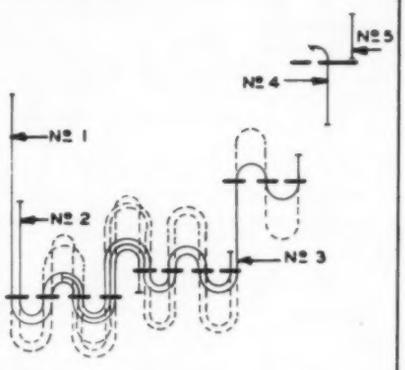
TWO BARS IN MILL

FIGURE – 3



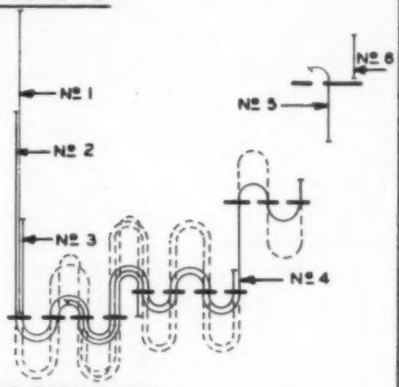
THREE BARS IN MILL

FIGURE – 4



FOUR BARS IN MILL

FIGURE – 5



FIVE BARS IN MILL
THREE BARS IN FINISHING STAND

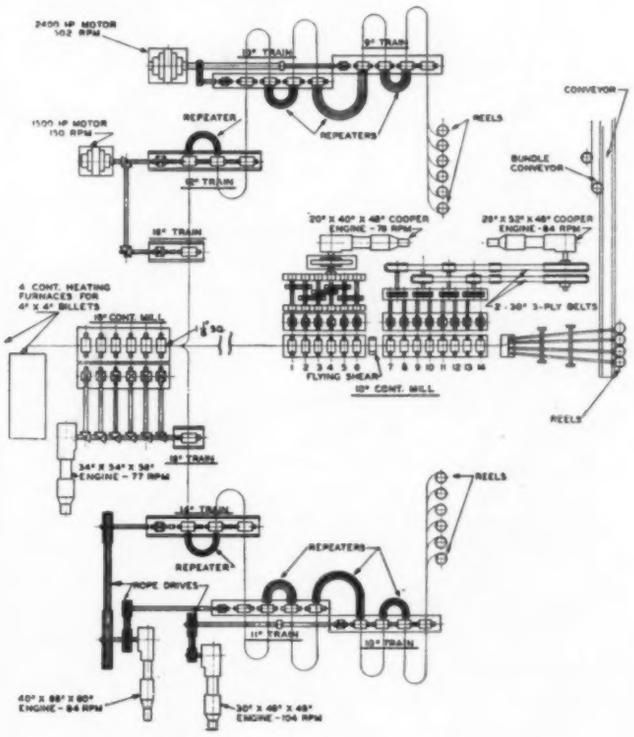
- PASS DATA -

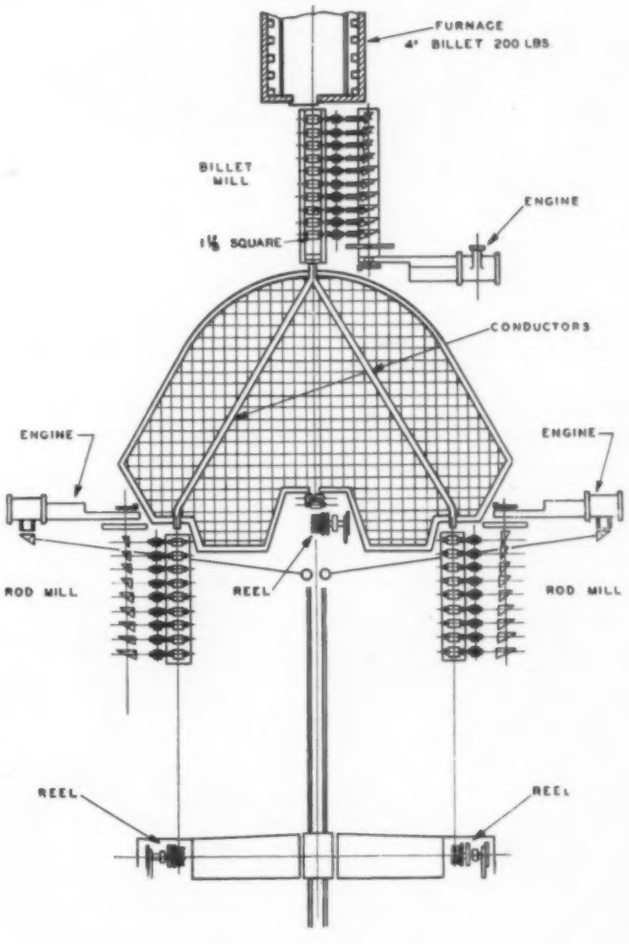
PASS	AREA	W.D.	R.P.M.
1	11.31	14.94	86
2	8.10	15.13	"
3	4.55	15.88	"
4	3.35	15.88	"
5	2.10	16.50	"
6	1.50	16.31	"
7	.780	16.63	"
8	.582	11.80	142
9	.322	12.37	"
10	.254	12.77	"
11	.134	9.89	345
12	.118	10.07	"
13	.0928	10.42	"
14	.0635	10.64	"
15	.0482	8.95	538
16	.0465	9.17	"
17	.0428	9.45	"
18	.0370	9.66	"

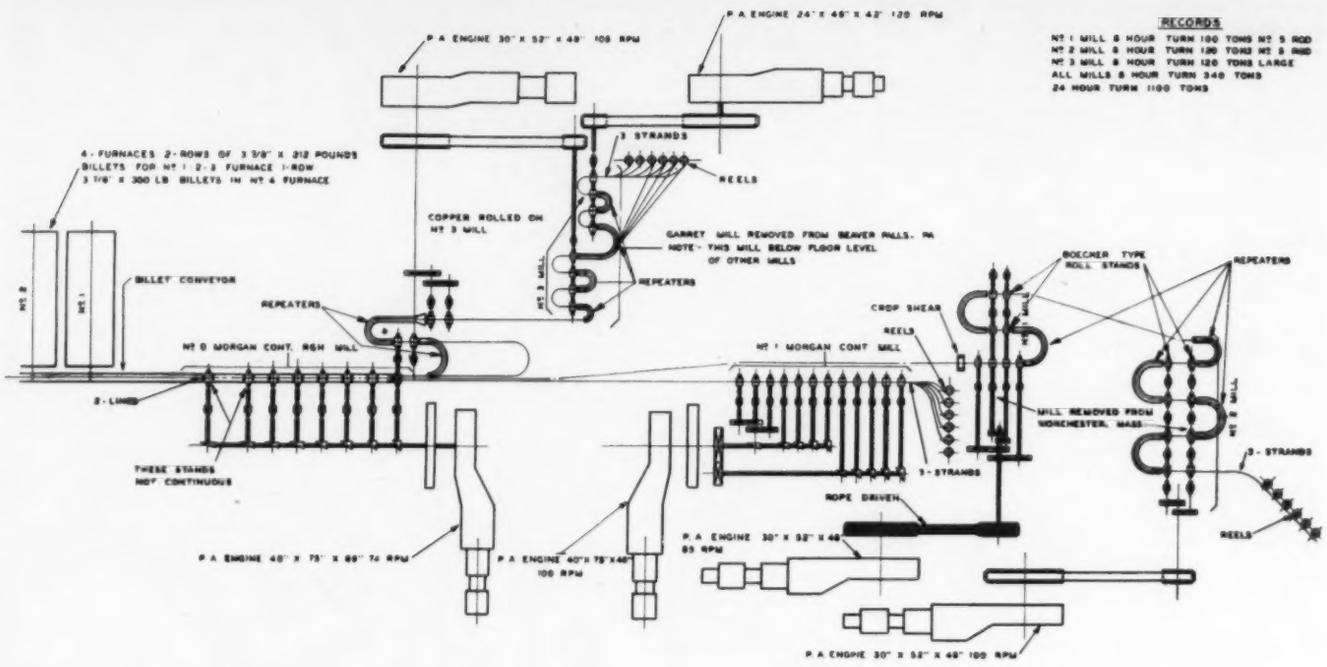
Drawing 19 (Above)—The rolling of more than one rod at a time was a big factor in increasing tonnage.

Drawing 20 (Below)—This continuous roughing mill feeds three rod mills.

Drawing 21 (Right) — This continuous rod mill was patented by F. H. Daniels in 1884.



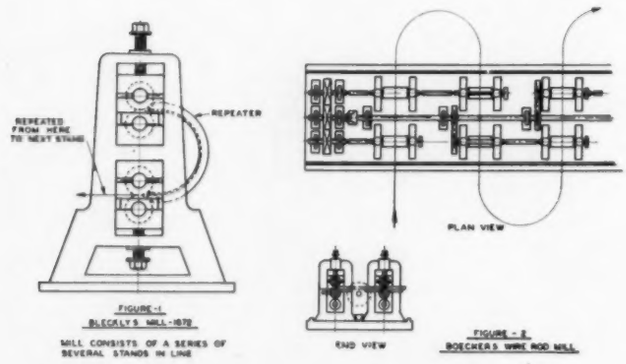



RECORDS
P A ENGINE 30" X 52" X 48" 105 RPM
P A ENGINE 24" X 48" X 42" 120 RPM
3 STRANDS
REELS
COPPER ROLLED ON Nº 3 MILL
GARRET MILL REMOVED FROM BEAVER FALLS, PA.
NOTE:- THIS MILL BELOW FLOOR LEVEL OF OTHER MILLS
REPEATERS
BILLET CONVEYOR
Nº 0 MORGAN CONT. R&H MILL
3 - LINES
THESE STANDS NOT CONTINUOUS
P A ENGINE 48" X 75" X 60" 74 RPM
P A ENGINE 40" X 78" X 48" 100 RPM
BOECKER TYPE ROLL STANDS
CROP SHEAR
Nº 1 MORGAN CONT MILL
MILL REMOVED FROM WORCHESTER, MASS.
3 - STRANDS
ROPE DRIVEN
P A ENGINE 30" X 52" X 48" 85 RPM
P A ENGINE 30" X 52" X 48" 100 RPM

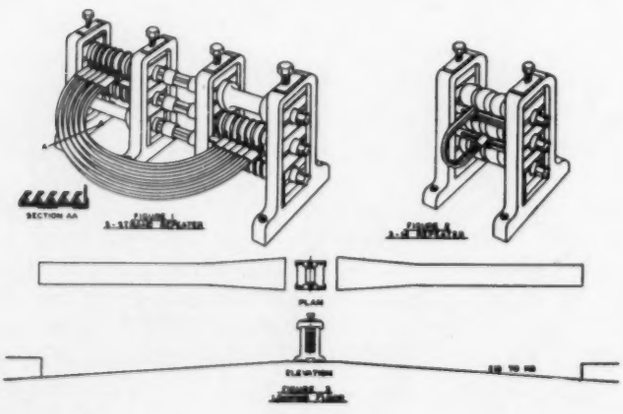
Drawing 22 (Above) — Rod mills at Waukegan, Illinois, 1891.

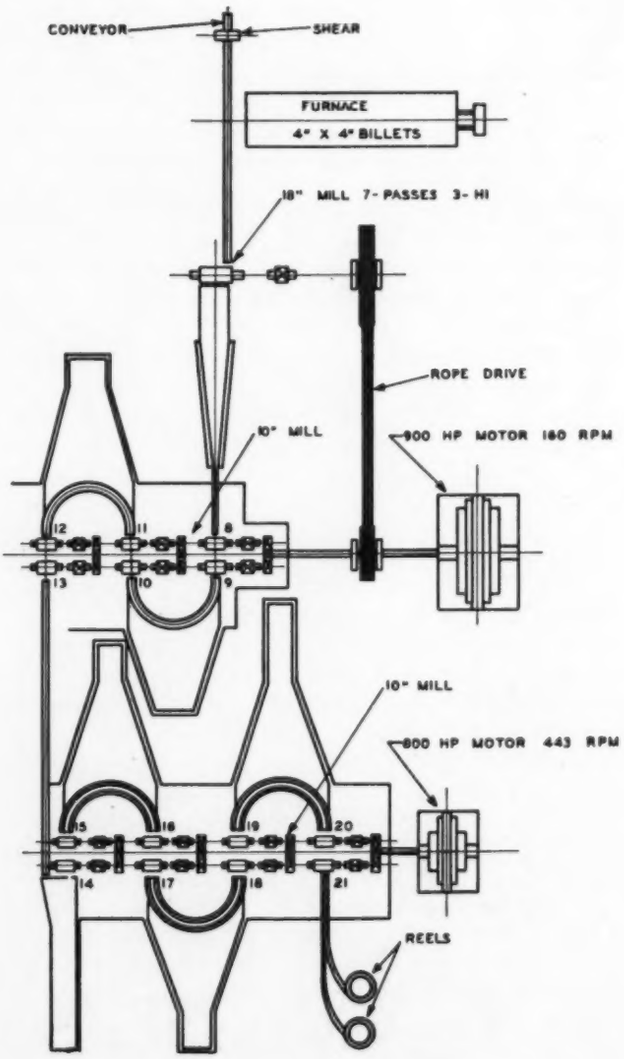
Drawing 25 (Below) — Rod mill with 3-high hand roughing.

Drawing 23 (Below) — Two old patented rod mills.



Drawing 24 (Below) — McCaleph and Quast rod repeater mills and looping floors.





Because of the lack of increasing roll speeds between stands in looping mills, a large loop is formed. On a flat looping floor, such loops often become tangled, and it was necessary to employ men or boys with hooks to pull on the ends of the loops to prevent them from tangling and causing cobbles.

H. Roberts and his roller A. T. Day of the Oliver and Roberts Wire Company in Pittsburgh constructed inclined floors where the loops would be extended by their own weight. The part of the floor where the operators stood was left level for safe footing. See Drawing 24, Figure 3.

Drawing 25 shows a rod mill with hook and tongs style roughing mill and a Boecker type finishing mill, a mill designed for a small building. It was intended to roll a maximum of two strands of rod and all the tong work was at the 18 in. three-high roughing stand, the finishing mill being provided with repeaters to loop square to oval and the oval to square twisted between the Boecker type continuous stands. The various stands are driven by gearing at a speed which minimizes loop length.

The mill rolled 4 × 4 in. billets into 0.218 in. rod in 21 passes, seven of which were forward and back passes in the 18 in. three-high roughing, the other fourteen passes being in the 10 in. finishing mill.

Drawing 26 shows a rod mill of 22 passes. This mill uses a 4 × 4 in. billet, and has a semi-continuous roughing line and a looping finishing train and the stands are speeded in such a fashion as to eliminate large loops, thus avoiding a great deal of the harmful cooling of the back end of the rod. The first four 17 in. stands are continuous and then a space is provided sufficient for a 275 pound bar to be free between the Number 4 pass and the Number 5 pass. Next in line are two continuous stands of 17 in. diameter rolls. Next is a space provided for side looping before entrance to the next continuous group of four stands of 17 in. rolls, and after this group the bars are looped through repeaters to the next two continuous stands of 14 in. rolls. The rods are then alternately looped and put through continuous stands for the rest of its travel. This mill with its provision for looping thus relieving harmful stretch in the continuous stands, is able to roll successfully No. 5 rod in 275 pound coils from the 4 × 4 in. billet.

The Garrett rod mills maintained their supremacy over the continuous mill for a number of years, because of the fact that their tonnage was greater than the continuous mills, and also their use of the 4 × 4 in. billet which was cheaper to produce than the small billets used on the continuous mills. Gradually the continuous mill came into greater favor through certain advantages inherent in the design. One of the greatest of these was the 30 foot billet 1¾ to 2 in. in size which became standard, and weighed 300 to 400 pounds as against the 4 × 4 in. billet which was rarely over 175 pounds in weight. Another advantage of the 30 foot billet was that the back end of the billet was still in the furnace, and kept at an even temperature until the very moment of entering the rolls, thus making for a fairly uniform rod gage from front to back of bar, while the Garrett mill billet lost much heat on the back end by radiation and contact with the floor while it was in the long loops. This resulted in considerable variation in tensile strength in the coil and was one of the main reasons why the 4 × 4 in. billets were kept down to about 170 pounds, as longer lengths would have still more variation from front to back. Another advantage of the continuous mill was the small crew employed. The Garrett mill required a large crew of relatively highly paid men.

Another factor which gave new life to the continuous mills was the cheaper small billets which were produced when the continuous billet mills came into the picture. The billet mills installed after the blooming mills, and rolling direct from the initial heat of the ingot produced small billets at a low cost, and one of the most serious objections to the continuous rolling rod mill was removed.

Drawing 27 illustrates a continuous rod mill erected around 1900. It was a fourteen pass mill using a 1¾ in. × 30 foot billet weighing 300 pounds. The first six stands were coupled closely. Then a space was left open before the next continuous group. This space provided an opportunity for a small side loop to form and relieve the bar from the pull received in the close coupled stands. Also a slight change made in the drafting in the last stands of the mill in many cases would not have to be carried further than the looped bar, the differences in elongation being absorbed in the loop.

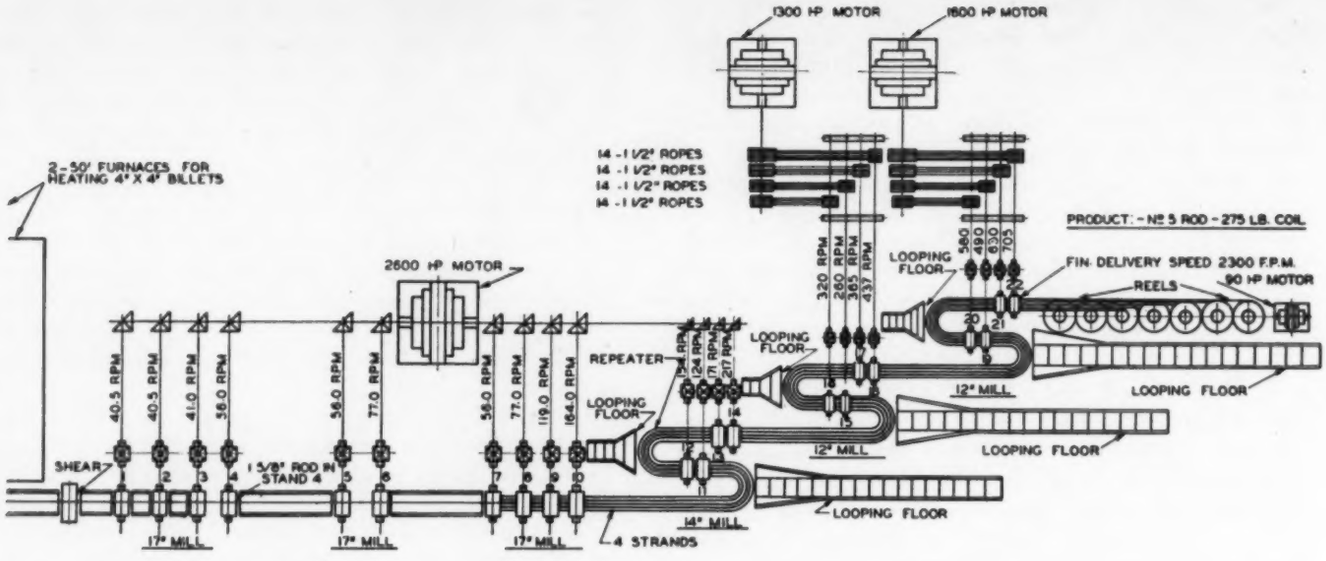
The billets for this mill were made on a two-high reversing blooming mill, the ingot being broken down in the usual drafting forward and back. The mill was then run forward for the last passes, the billet being looped around the end of the housing through repeaters enough times to produce a 1¾ in. square the last time through.

Drawing 28 illustrates a continuous rod mill of 16 passes. This 16 pass mill was a common one of the early 1900's and used a 1¾ to 2 in. billet. A flying shear was used after the sixth stand to crop the front ends of the bar. The cropping of the bar insured a clean front end which in turn gave assurance that a bad end would not cause a cobble.

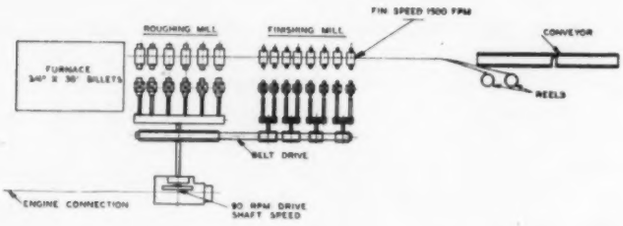
Drawing 29 shows a rod mill of 18 stands with two interruptions in the continuous lines to provide two loops. These loops are thought to be an improvement inasmuch as they afford a chance for some regulation of drafting free from the stretch which occurs between the continuous stands. The mill finishes 3 to 4 strands of rod.

Drawing 30 illustrates a continuous rod mill, one of the newer types. The mill takes a 1⅝ in. billet 30 feet long. After the first 7 stands of 12 in. rolls there is a flying crop chear, in a twenty foot space between mills. Then there is a four-stand 10 in. intermediate and roughing mill. Next there is space provided for a slight loop in the bars to relieve stretching. Following are two stands of a 10 in. preliminary mill and from these stands there is a looping trough to the twin 9 in. continuous finishing mills. Three coilers are provided for each mill. There are a total of 17 passes including the first one which takes a very moderate draft.

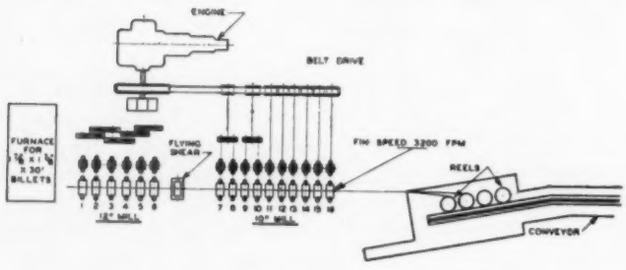
One of the newer installations in rod mills is shown on Drawing 31. The installation consists of two similar rod mills side by side. The continuous furnaces are for 30 foot billets 2 in. × 2 in. in size and weighing 400 pounds. The first eight continuous stands are of 12 in. rolls. A flying shear after this group crops the front end of the bars. The second group of roll stands has 10



Drawing 26 — Fairfield Works semi-continuous looping rod mill.

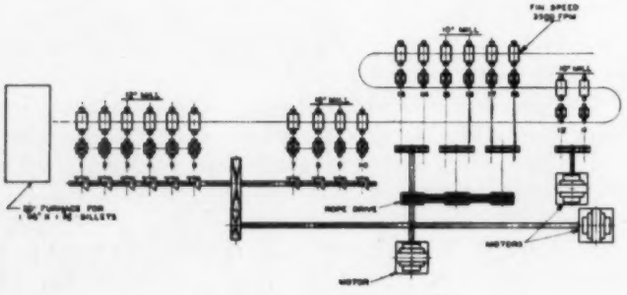


Drawing 27 — This 14 pass continuous rod mill was erected about 1900.



Drawing 28 — This 16 pass continuous rod mill was in common use in the early 1900's.

Drawing 29 (Below) — Continuous looping rod mill.



passes and the rolls are 10 in. nominal diameter. The total number of passes from the billet is 18. The finishing speed is 3600 feet per minute with two strand operation. The mill averages close to 17 tons of No. 5 rod per hour for each mill.

One of the newest rod mill installations is located in the middle west. See Drawing 32, Figure 1. Figure 1 shows two 11 in. mills side by side. These mills are designed to roll rods from No. 5 to about ½ in. diameter. One of the mills rolls No. 5 rod most of the time while the other covers the size range.

These mills are equipped with roller bearings for the roll necks. Each mill rolls three strands of rods at a time and finishes rods at the rate of about 3500 fpm. The mills use 2 5/16 in. billets 30 feet long.

Parallel with these two mills a newer mill has been built, see Figure 2. This mill is for the larger size rods, 5/16 to ¾ in. in diameter, and uses a 2½ in. billet, also 30 feet long. While the 11 in. mills are driven by one motor, this mill does not have more than two stands driven by one motor and the leader and finishing have individual motors. The distinctive feature is the two separate finishing mills. The mill rolls three strands of rod through the roughing and intermediate stands and alternating two and one through the last two stands. These mills will soon be rolling four strands at one time.

One of the recent rod mill installations which is also equipped to roll bars is illustrated in Drawing 33. This mill is built to roll 4 strands of rods and has a hot bed for rolling bars out of the 14th stand, and reels also for product from this stand. This mill is of the latest design and has rolled 50 tons per hour of No. 5 rod. It is distinguished by having two loops with repeaters as is customary with this particular design.

Another installation for the purpose of rolling both rods and bars is shown on Drawing 34. All of the sizes are as a rule rolled from a 2 3/16 in. billet, although provision has been made to use billets as large as 3 in. The billets are 30 feet long. The mill rolls rods from No. 5 to 13/32 in. and rounds up to ⅞ in. in diameter. When using the twin 9 in. finishing trains, the mill has as many as three rods passing through the finishing rolls. The mill has rolled as high as 338 tons of No. 5 rod in

8 hours. Although only two rods at a time go through the roughing line, three rods or more can be rolled in the finishing train by speeding up the roughing train and allowing long loops to form in the intermediate trains, thus permitting bars from the roughing to catch up with those in the finishing trains.

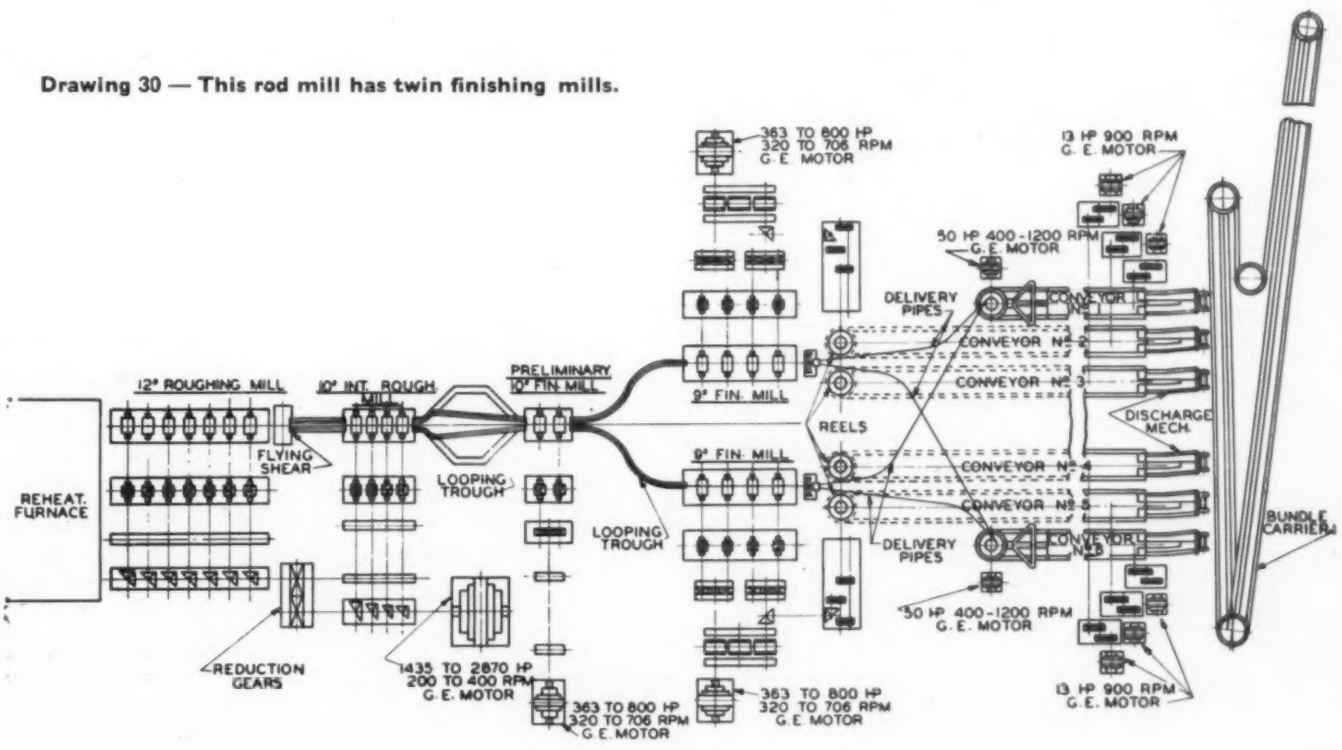
As Bedson was the first successful producer of rods rolled continuously, it is of interest to trace the further development of his mills. In all, three of the Bedson mills were built in one English plant. The first was the original mill, another mill of the same type was also built, and one somewhat later of the horizontal roll type. The 16 pass alternate horizontal and vertical mill had at one time been rolling 1¼ in. billets into No. 6 rods and had considerable trouble due to split ends, causing cobbles. There was from 6 to 7 per cent scrap from this cause. There also was another Bedson mill in the plant. The management of the plant rebuilt and rearranged the two mills to form one mill as shown on Drawing 35. Ten of the alternate horizontal and vertical roll stands were arranged to take a 2 in. billet and in the 10 passes reduce it to a ½ in. square. At this point provision was made for a loop. A catcher caught the bar as it came from the 10 stand train, looped the bar, at the same time cutting off a few inches of the front end, and then entered the bar in the second continuous mill, which consisted of six stands of alternate horizontal and vertical roll stands, a part of the two former mills. As the bar emerged from the last stand of this mill in an oval form, it was caught by a catcher and poked in a two-high finishing stand, and from there went to the reels. The scrap on this combination was less than 3 per cent and the mill rolled around 40 tons per turn.

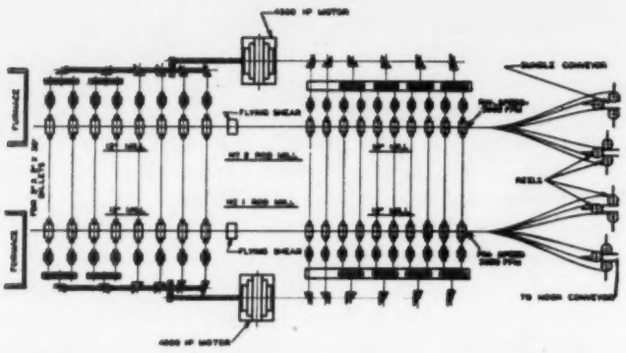
Among foreign rod mills, one of a rather unique design was built at Duisberg, Hochfield, Germany. The mill, as it originally stood, was part continuous and part looping mill. The remodeled mill is shown in Drawing 36. The mill was arranged so as to leave the looping mill in place and some continuous stands were added. One of the unusual features of the mill is the four-high stands, No. 10, 11 and 12. These were necessary to carry two lines of rods, one line in the upper two rolls for the new mill, and the other which feeds the old looping mill in the two lower rolls. The mill uses a 5⅛ in. billet of 440 pounds weight. In the first six continuous stands this is reduced to 1.81 in. square. After the sixth stand, the bar is cut in two by flying shears. The two pieces enter the next stands together, passing through a heated trough in front of the next continuous group. Bars for the old mill go through six continuous passes, which reduce them to 0.493 in. square. They then go on through 4 looping stands of 12.8 in. diameter rolls and next through 6 looping stands of roll diameters varying from 10.25 in. to 11.40 in. and finish to 0.197 in. rods.

The new continuous mill takes two rods at a time. The first stands the bar passes through are eight in number in groups of two. Immediately after the first two is a drum type cropping shear. Between each group of two stands is provision for a slight loop. After passing through these 8 stands the bars go to the twin four-stand finishing mills, one rod to each mill. This finishing mill is unusual in design. The stands are alternate vertical and horizontal and each stand is individually driven by a motor.

The vertical stands have the oval passes. The driving motor is overhead and the housings and motor are set on shoes which are inclined 45 degrees. The purpose of this 45 degree base is to allow the vertical rolls to move up or down on the angle base and by so doing, the vertical roll passes can be lined up with the horizontal ones as shown on the drawing.

Drawing 30 — This rod mill has twin finishing mills.





Drawing 31 — This 18 pass continuous rod mill has a finishing speed of 3600 fpm.

ROD REELS

In the early rod mills the rods were coiled into a bundle. The reels were very simple and were operated by a boy. The rod as it emerged from the rod train finishing stand was guided into a series of hairpin curves on the mill floor. A boy picked up the front end of the rod with tongs and inserted the end in the reel, and the boy operating the reel reeled the rod up into a bundle, after which the bundle was removed from the reel. This was the practice in the early type rod mills.

As the rod mills progressed and the rod lengths became longer it became a hard, tough job to reel the rods. A friction power driven reel was then developed and added to the early hand operated reel as shown in Figure 1, Drawing 37. This sufficed for a time, but better reeling methods were needed in order to permit the mills to roll at their full capacity. Full capacity on the mills meant from 2 to 7 strands of rods at one time and at high speed, speed beyond the capacity of any hand or friction driven apparatus.

The automatic stick in and reeling apparatus was invented in 1886. One of these, a laying reel, is shown in Figure 2. In the laying reel, the action of the laying pipe caused the rod to become twisted somewhat. This did not cause any particular trouble for the wire drawer, in fact, some preferred it this way.

Another design of 1895 is shown in Figure 3. In this design, the reel separates after the coil is on it and allows the coil to drop into a trough and roll out of the way.

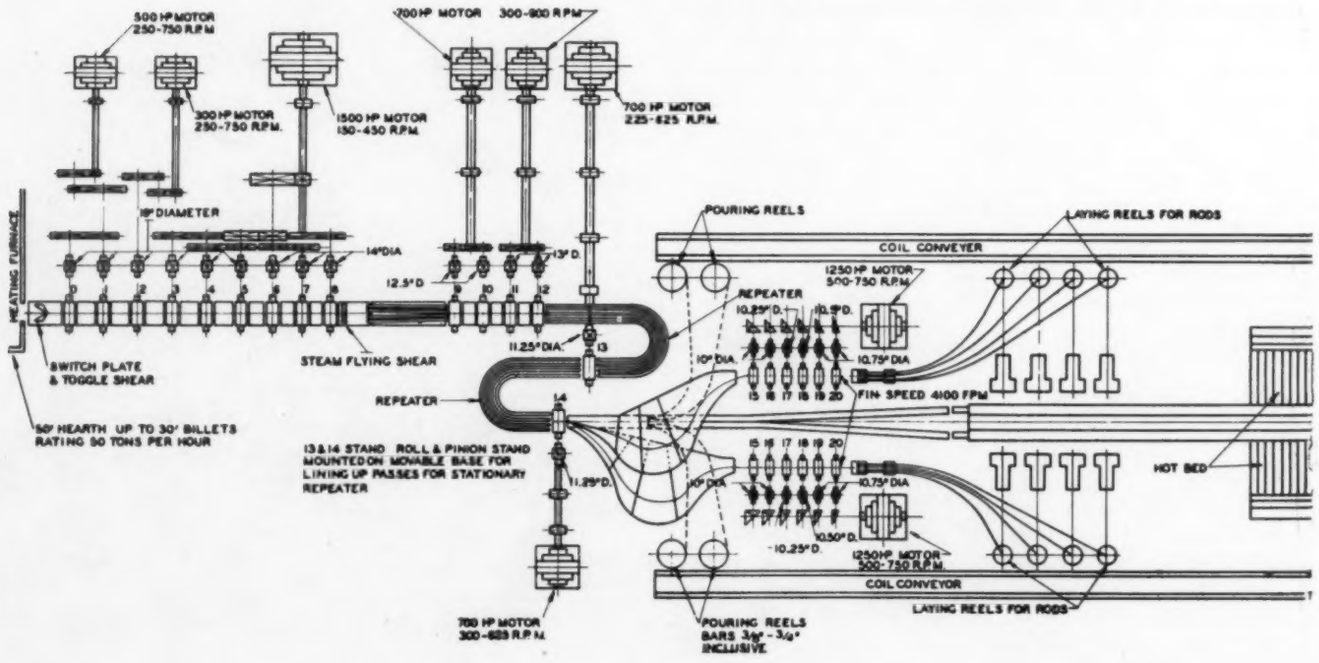
In Figure 4 is shown one of the later designs of pouring reels as used on a late design rod mill.

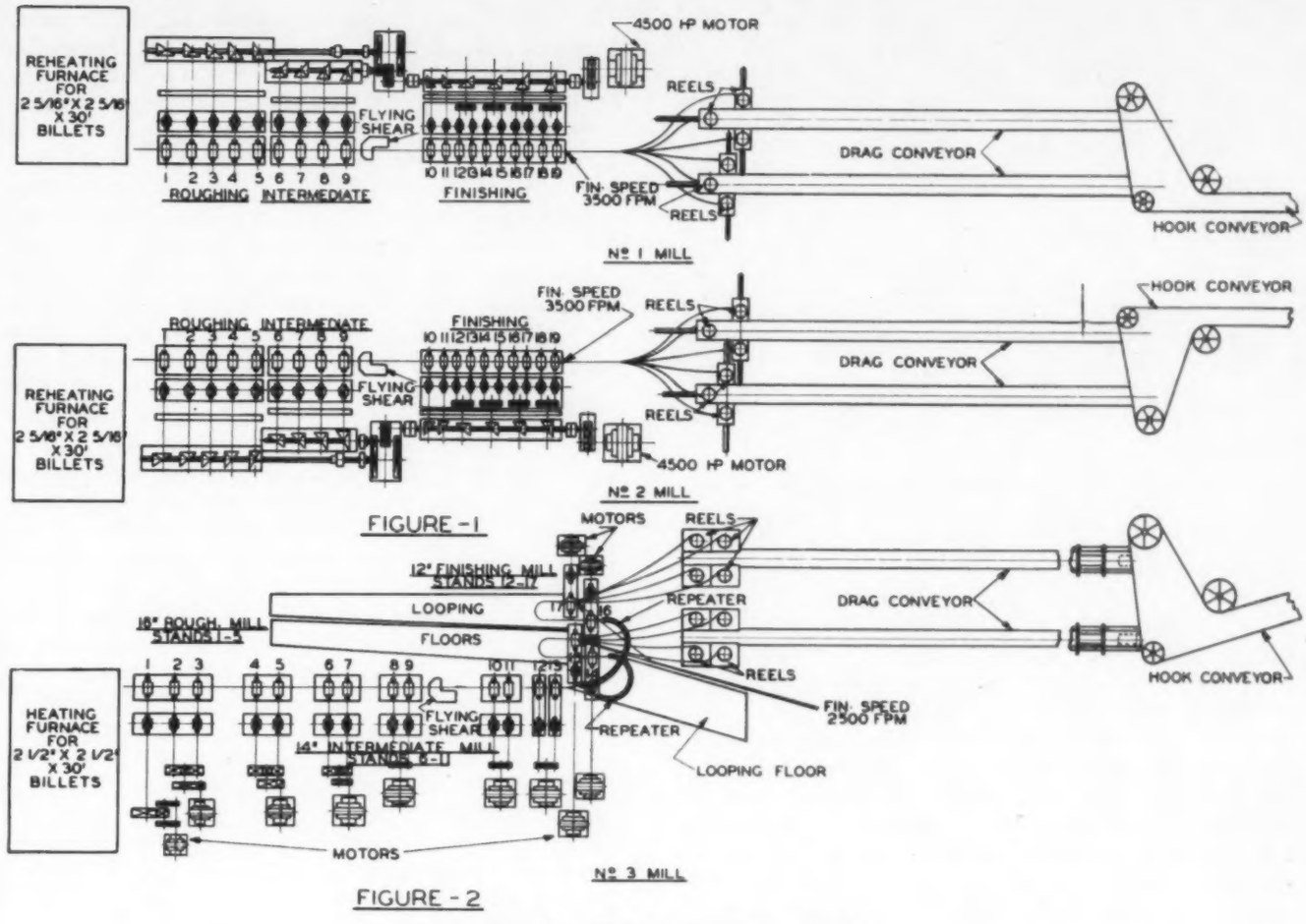
On Drawing 38 is shown a rod mill finishing housing design. Though not of the latest design, it is still in use. In a continuous rod mill of the type using this housing, the rod must pass in a straight line through the mill. Bottom adjustment is provided in the housing to line the bottom rolls up in order that a level line can be had through the passes. The top roll is lined down. The bearings between the rolls feature a wedge device which serves to take spring out of the rolls and also provides a braking action on the rolls and keeps the spindles and boxes tight between the pinions and rolls so that there is no harmful backlash which might cause a cobble.

ROD MILL ROLL DESIGN

Henry Cort is credited with building the first practical rolling mill for bars, and he might be said to have been the first roll designer. In common with many inventors, he did not achieve great financial success through his inventions. Cort was born in 1740 at Lancaster, England, and at the age of 25 was a ships broker and among other commodities he sold iron for ships. The iron was of poor quality and this led to his experimenting in iron production. He had saved some money in his brokerage business, and spent it all in perfecting his process. He built his works at Fontley, England, and

Drawing 32 — These straight continuous rod mills are equipped with anti-friction bearings.


500 HP MOTOR 250-750 R.P.M.
700 HP MOTOR 300-900 R.P.M.
300 HP MOTOR 250-750 R.P.M.
1500 HP MOTOR 150-450 R.P.M.
700 HP MOTOR 225-825 R.P.M.
HEATING FURNACE
SWITCH PLATE & TOGGLE SHEAR
50' HEARTH UP TO 30' BILLETS RATING 50 TONS PER HOUR
STEAM FLYING SHEAR
13 & 14 STAND ROLL & PINION STAND MOUNTED ON MOVABLE BASE FOR LINING UP PASSES FOR STATIONARY REPEATER
REPEATER
POURING REELS
COIL CONVEYER
LAYING REELS FOR RODS
1250 HP MOTOR 500-750 R.P.M.
FIN. SPEED 4100 FPM
HOT BED
700 HP MOTOR 300-825 R.P.M.
POURING REELS BARS 3/8" - 3/4" INCLUSIVE



Drawing 33 — Modern 4-strand rod mill.

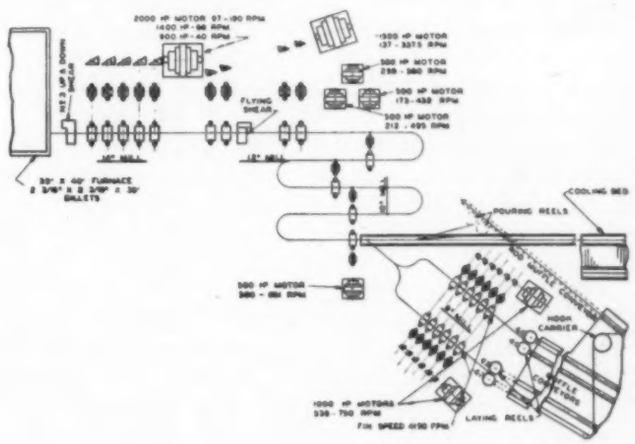
from 1777 to 1783 labored to perfect his inventions and obtained his patents in 1783 and 1784. Though the puddle furnaces and mills were successful, he lost all his possessions, including his patents through misfortunes and died poor. The far reaching benefit of Cort's processes in the early iron work can be realized when one learns that in 1787 in one English plant, using hammers, ten tons of bar iron a week was a good week's work. This same works adopted Cort's process and 25 years later, in 1812, was making 200 tons per week or a 1900 per cent increase in production.

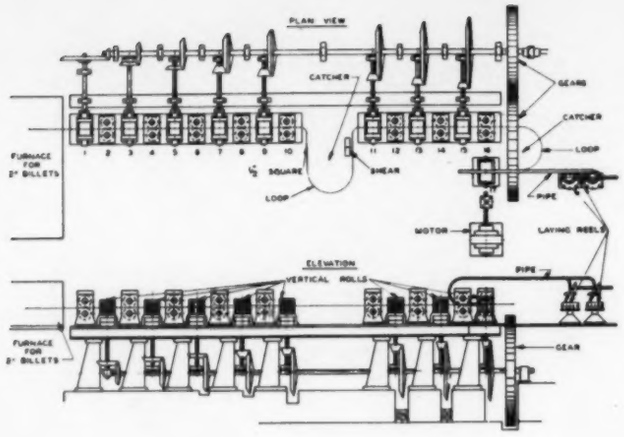
In writing of rod mill design it is difficult to find material in which a difference in design can be noted, since all the pass layouts, with few exceptions, either have box and edge passes, diamond square, open squares, or some form of oval and square. When these passes have been described there is very little more to say regarding the shape of rod mill passes. All further descriptions must be of details of draft on the various types of passes.

The pass designs used on the first Cort mill were gothic passes, which were particularly well designed to take the puddle ball after it had been hammered. Any billets which were rolled direct from the puddle bloom were finished in this gothic pass set of rolls. A design of gothic pass used in Wales in the early days of rolling is shown in Figure 1, Drawing 39. The passes shown are the first two of nine passes. The passes not shown are in much the same proportions as the first two though decreasing in size. The flat spots at the bottom of the passes are designed so that the bar when turned into the succeeding passes will not fin too badly. The bars being turned 90 degrees from pass to pass, the flat spot comes in the roll parting and provides for spread. The shape of these passes approximates that of a round and thus the corners retain heat better than a diamond which would have more nearly sharp corners.

The angle of these passes is 98 degrees as shown. The angle of the more modern passes as used in the bar mills of this country in working iron was from 96 to

Drawing 34 — This continuous looping rod mill can roll both rods and bars.





Drawing 35 — Remodeled Bedson rod mill.

98 degrees so that it is evident that very little, if any, change has been made from the early design of these passes. The quality of billets rolled direct from the puddled bloom was not of the best. They were full of cinder and not homogenous. Better billets were made by rolling the puddle blooms into flats, and later piling the bars into bundles, heating and rolling into billets. Probably this practice led to the development of the box and edge passes, see Figure 2. These passes are particularly well adapted to rolling a puddle iron pile and quickly welding it. Box passes were as a general rule only used for the first two to four passes and were followed by gothics. Box passes must have been developed before 1800, as the inventor, John Hazeldine, shows these passes in his patented mills of 1798. Figure 3, Drawing 39 shows the manner of piling puddle iron piles. These piles were used in England for rolling billets for telegraph wire in the period of 1850 to 1860.

The best quality of iron for wire drawing was produced from these piles. It was necessary to have charcoal iron for stock on the outside of the piles and also to roll the iron two or three times to eliminate cinder and other impurities from the iron. The billets on the inside of the pile were made from a fair quality of puddled iron.

In the rolling of material for rods in the earliest mills, such as Cort's two-high mill, it was not practical to roll the rounds used for the wire to a small size. It is known that some rods were produced as small as 1 in. in diameter in the rolling mill and further reduced to about ¼ in. diameter by hammering after which the material was drawn into wire.

The date at which three-high mills for small bar sizes were introduced is not definitely known, but from the reports of plant visitors in England it is certain they were is use there before 1817. The Belgian rod mills of that period also utilized a three-high roughing stand, and as the first Belgian type rod mill to be installed in Germany is said to have been built in 1817, it is evident that three-high mills were in use in Belgium before this date.

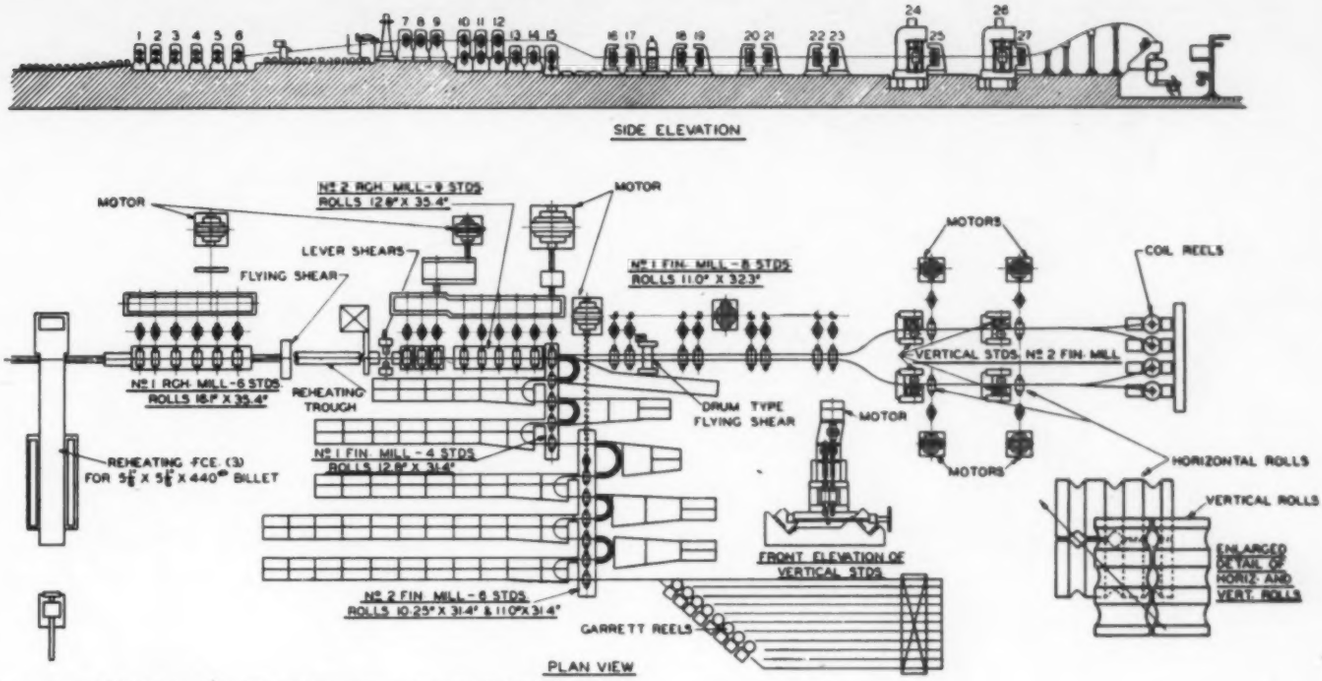
With the use of the three-high mill for roughing down the billets, it was possible to roll the iron to smaller sizes for drawing and ½ in. diameter rounds were rolled by the hand round method. It is also known that the use of oval and diamond and square passes were developed at about the same time. No doubt, the early roll designers and rollers discovered that gothic passes would not give a very rapid reduction in the smaller sizes, see Figure 1, Drawing 40, where a 20.4 per cent reduction overfills the pass. In endeavoring to secure faster reduction, the designers made the gothic passes in the small sizes flatter, and with larger corner fillets, see Figure 2, Drawing 40, which made them somewhat in the form of an oval. This form of pass, however, was difficult, if not impossible, to hold up in entering a similar pass, but it was found that the pass could be entered into a gothic square without too much difficulty, see Figure 3, Drawing 40. In entering this gothic square into a much flatter gothic, it was soon discovered that the square would not enter on the edge but would turn over on the flat, see Figure 4, Drawing 40. This was a close approach to the modern way of rolling in the oval square method. This is believed to be the way the oval and square, with its fast reduction, was evolved. At that time it was found that flat gothic sections of this kind could be held up in entering a gothic square by close fitting entering guides, see Figure 5.

From these experiments it was only a step to the rolling of guide rounds. The same flat gothic could be used to produce a rough sort of round if entered into a round pass and held up with guides, see Figure 6, Drawing 40. As an oval of this kind with flat sides entering a round pass would be subject to overfills and underfills along the bar, it was soon modified into the round oval as we know it today, see Figure 7. A somewhat flatter oval was designed to use in the breaking down passes and was introduced into a square with excellent reduction percentage, see Figure 8.

The invention of the telegraph about 1837 caused a great demand for telegraph wire, and bar mills were soon adapted to roll small rounds or new ones were built for the purpose. As a finished guide round cannot be accurately made to close tolerances in a three-high finishing set, the two-high set which had been formerly used for flats was set up with round passes and guides to hold the ovals entering the round. The rod train then consisted of a three-high roughing, a three-high strand set, and the two-high finishing rolls. The billet was small, about 1 to 1¼ in. and about ten to fifteen pounds in weight. The size rolled at first was ¼ in, and the passes were oval-square down to the leading oval and then the round pass. It is known that this form of rolling was in use between 1800 and 1820. It usually took 12 to 13 passes to reduce a 1¼ in. billet into ¼ in. rod by this form of rolling.

This form of rolling rods continued for some years. The roll trains were gradually increased to 4, 5, 6, and even 7 stands in line, but the billet sizes were not appreciably increased beyond the 1⅛ to 2 in. size until the advent of the separate roughing stand which was placed in front of the finishing train, when the billet size was increased somewhat. The method of reduction in most cases was still oval and square, the most rapid method of reduction both in the early times and today. Rods of small size could not have been produced without the use of the oval and square design.

Diamond passes were used also, but at the best even the flatest diamond will not equal the reduction of oval and square. Diamond pass roughing rolls, though, were used rather early in the mills and were and are capable of greater reduction than the gothic passes.



Drawing 36 (Above)— This German rod mill at Duisberg, Germany is an unusual design.

Drawing 37 (Below and Right) — Development of rod reels.

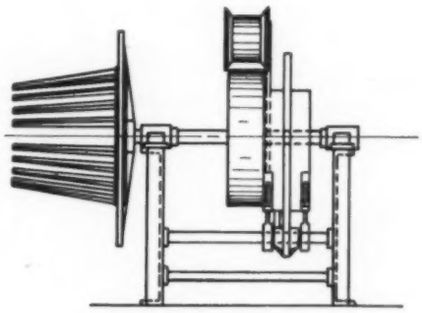


FIGURE - 1

EARLY REEL WITH FRICTION DRIVE - 1870

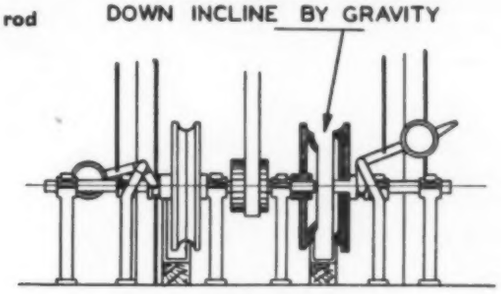


FIGURE - 3

MECHANICAL GARRETT REEL - 1895

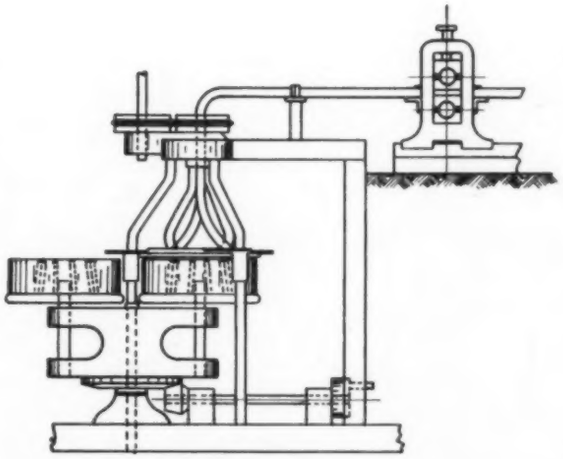


FIGURE - 2

LAYING REEL - C. H. MORGAN - 1886

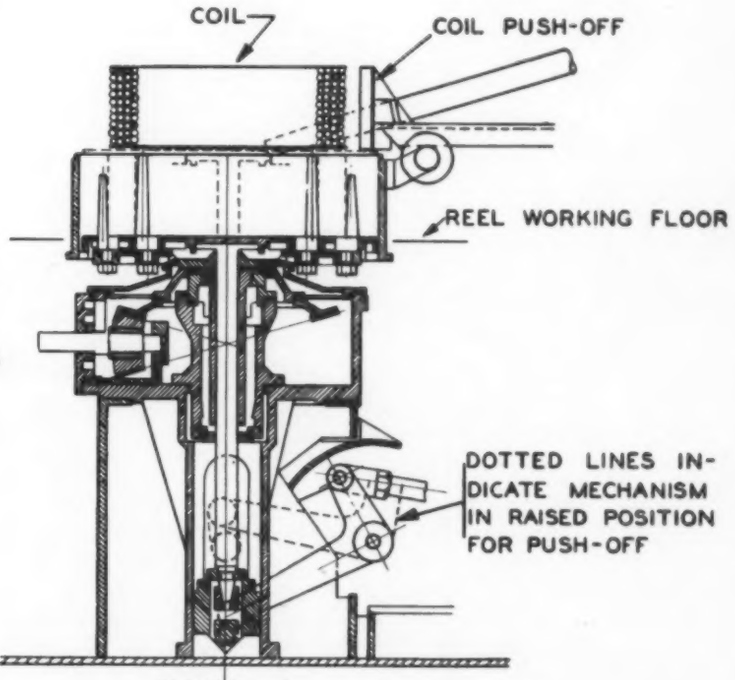
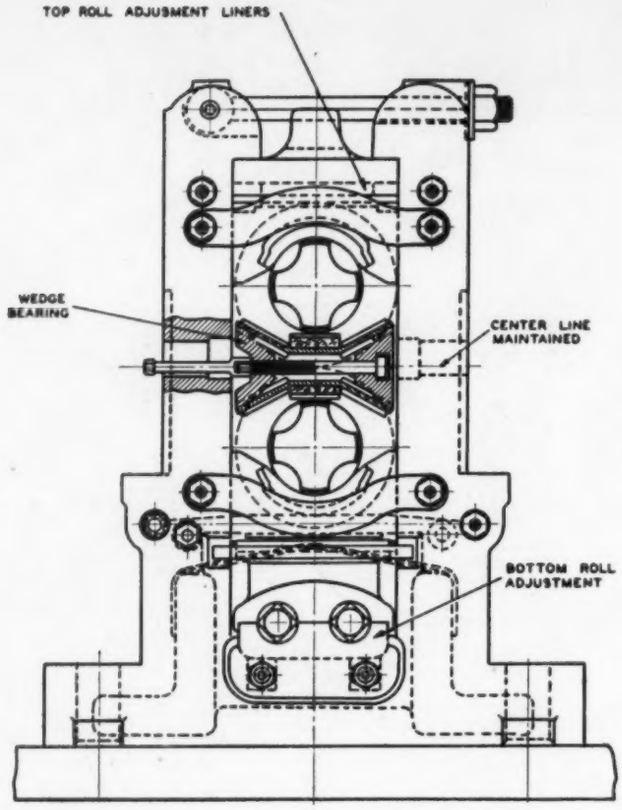
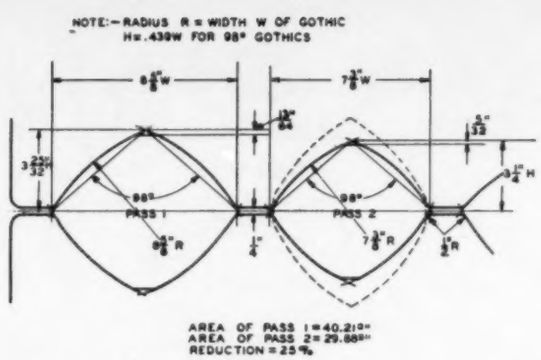


FIGURE - 4

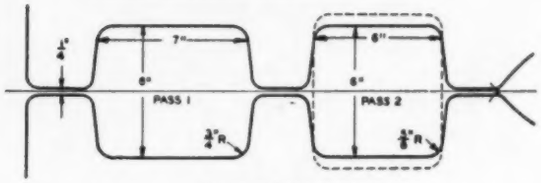
MODERN POURING REEL





AREA OF PASS 1=40.21"
AREA OF PASS 2=29.88"
REDUCTION = 25%

FIGURE-1
GOTHIC ROUGHING PASSES



AREA OF PASS 1=41.52"
AREA OF PASS 2=35.88"
REDUCTION=4.2%

FIGURE - 2
BOX ROUGHING PASSES

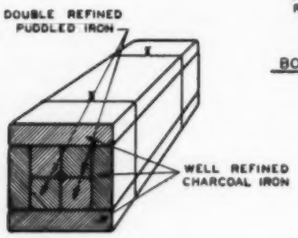
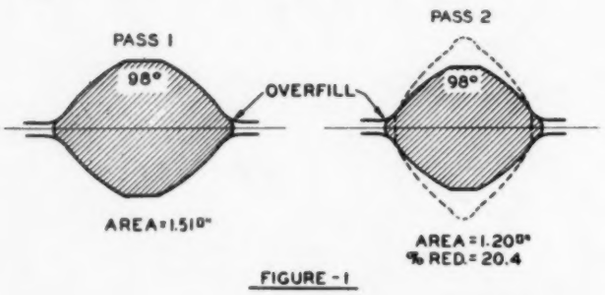


FIGURE - 3
BOX PILE

Drawing 38 (Above, left) — Rod mill roll housing.

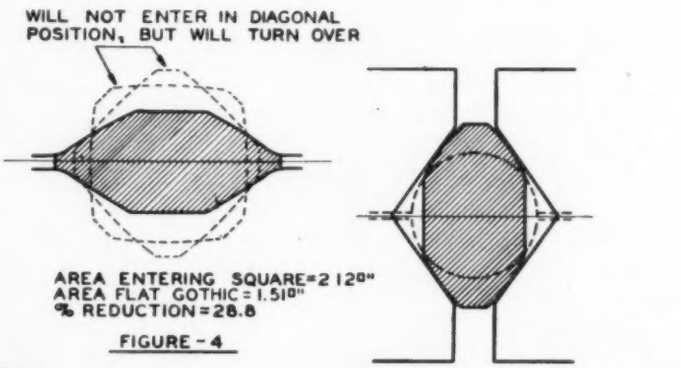
Drawing 39 (Above, right) — A comparison of gothic and box roughing passes is given in Figures 1 and 2. Figure 3 shows an iron pile for rod billets.

Drawing 40 (Below) — Evolution of oval-square passes.



AREA=1.51"
AREA=1.20"
% RED.=20.4

FIGURE-1

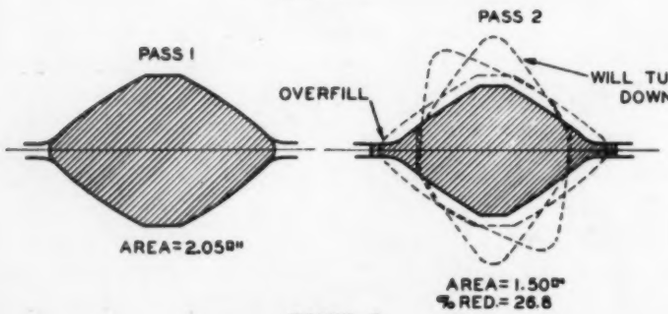


AREA ENTERING SQUARE=2.12"
AREA FLAT GOTHIC=1.51"
% REDUCTION=28.8

FIGURE-4

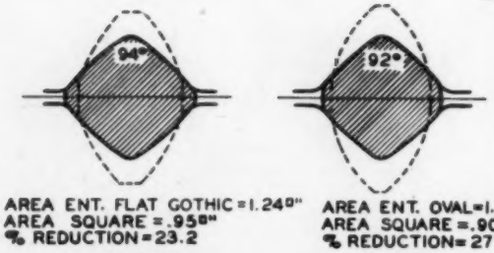
AREA ENT. FLAT GOTHIC=1.43"
AREA ROUND=1.15"
% REDUCTION=19.7

FIGURE-6



AREA=2.05"
AREA=1.50"
% RED.=26.8

FIGURE-2



AREA ENT. FLAT GOTHIC=1.24"
AREA SQUARE=.95"
% REDUCTION=23.2

FIGURE-3

AREA ENT. OVAL=1.23"
AREA SQUARE=.90"
% REDUCTION=27

FIGURE-8

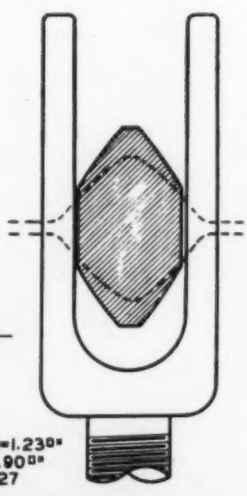
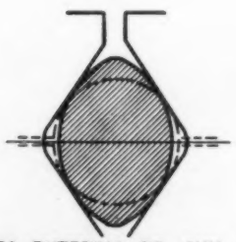


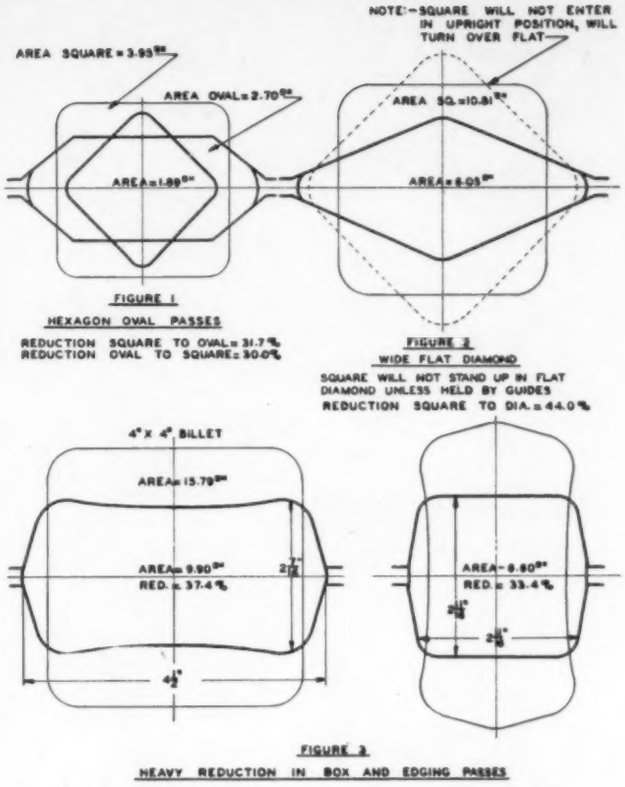
FIGURE-5



AREA ENTERING RD. OVAL = 1.28"
AREA FINISHING ROUND = 1.15"
% REDUCTION = 10.3

FIGURE-7

FLAT GOTHIC ENTERING


NOTE:-SQUARE WILL NOT ENTER IN UPRIGHT POSITION, WILL TURN OVER FLAT
AREA SQUARE = 3.93 SQ IN
AREA OVAL = 2.70 SQ IN
AREA = 1.89 SQ IN
FIGURE 1
HEXAGON OVAL PASSES
REDUCTION SQUARE TO OVAL = 31.7 %
REDUCTION OVAL TO SQUARE = 30.0 %
AREA SQ. = 10.81 SQ IN
AREA = 6.05 SQ IN
FIGURE 2
WIDE FLAT DIAMOND
SQUARE WILL NOT STAND UP IN FLAT DIAMOND UNLESS HELD BY GUIDES
REDUCTION SQUARE TO DIA. = 44.0 %
4" X 4" BILLET
AREA = 15.79 SQ IN
AREA = 9.90 SQ IN
RED. = 37.4 %
AREA = 8.80 SQ IN
RED. = 33.4 %
FIGURE 3
HEAVY REDUCTION IN BOX AND EDGING PASSES

Drawing 41 — Roughing passes for rod mills.

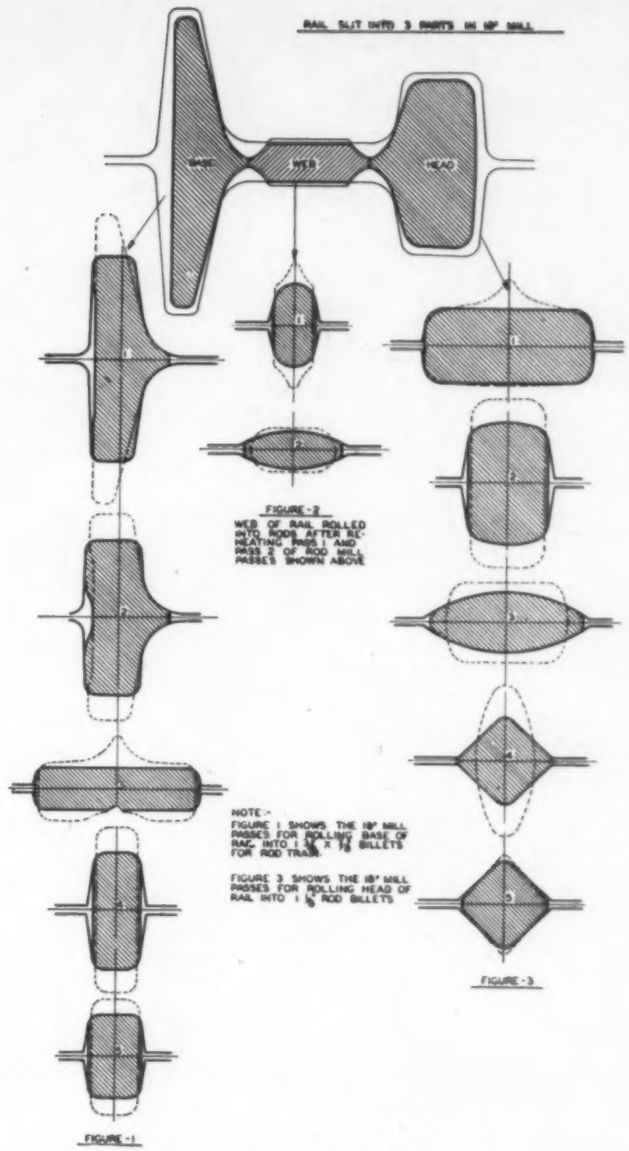
Sometime in the past a type of pass was developed which has somewhat greater draft possibilities than the oval-square. This form of pass is sometimes referred to as the hexagon-oval, see Figure 1, Drawing 41. The flat sides and tapered ends of this pass restrict spread of square to oval in a marked degree, so much so that it is very difficult to fill the oval, and from oval to square the reduction is greater than from the conventional oval to square.

Box and edge passes were used to some extent in roughing passes, particularly for the use of box piles, the shape of the pass lending itself admirably to the welding of the pile. For the intermediate and finishing passes for small bars or rods, box passes are worthless as very little reduction can be accomplished in this form of pass on small sizes, and bars would become too cold due to the increased number of passes required.

In the Belgian type roughing roll stands, box and edge passes are useful on billets of 3 to 4 in. size. Billets of this size, as rolled on two-high reversing mills, are very irregular in size, and an irregular sized billet entering either oval or diamond passes is inclined to lean in the pass and, in general, does not fill the pass satisfactorily. A box pass, however, will take such a billet satisfactorily and correct the tendency to lean of diamond shaped billets.

Thus, in many of the roughing stands of a rod mill using 3 to 4 in. billets, box and edge passes are used as pass one and two. After these passes the reduction is accomplished in oval and square passes.

Many attempts have been made to equal the reduction of the oval-square method. Diamond passes have been made very flat and with angles as much as 132 degrees in the attempt to equal the oval in reduction.


RAIL SLIT INTO 3 PARTS IN 18" MILL
BASE
WEB
HEAD
FIGURE-2
WEB OF RAIL ROLLED INTO BOOK AFTER RE-HEATING PASS 1 AND PASS 2 OF ROD MILL PASSES SHOWN ABOVE
NOTE:-
FIGURE 1 SHOWS THE 18" MILL PASSES FOR ROLLING BASE OF RAIL INTO 1 1/4" X 1 1/8" BILLETS FOR ROD TRAIN.
FIGURE 3 SHOWS THE 18" MILL PASSES FOR ROLLING HEAD OF RAIL INTO 1 1/8" ROD BILLETS
FIGURE-3
FIGURE-1

Drawing 42 — As early as 1869, rails were slit for use in rod billets.

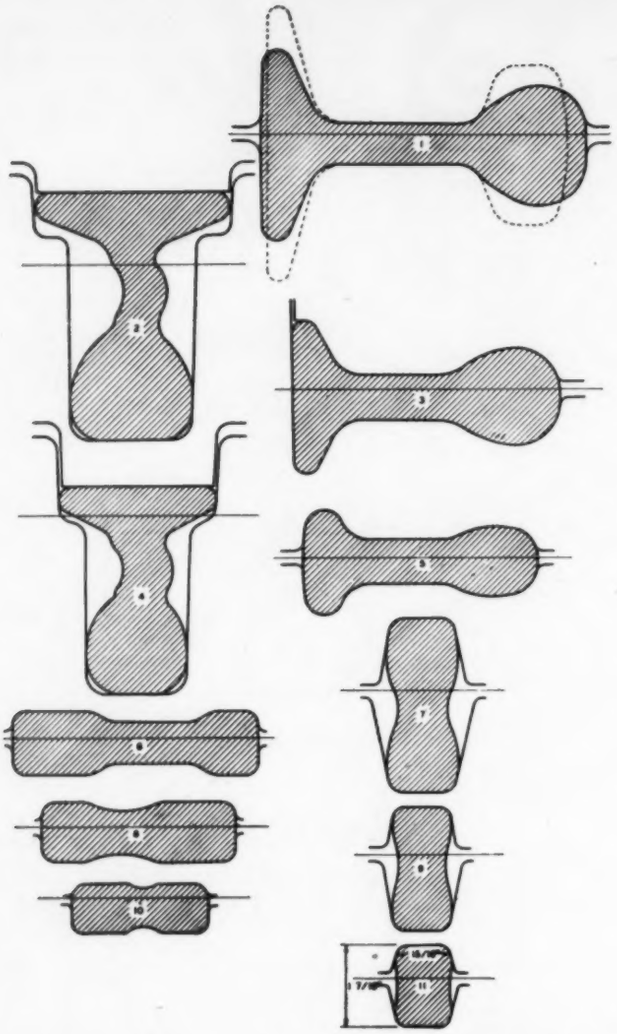
A square entering a diamond of this degree will not enter in the usual manner, it will roll over and enter in the flat position unless held by guides. See Figure 2.

Figure 3 shows an extreme reduction accomplished in a box and edge design. Heavy reductions like this cannot be done unless the rolls are heavily ragged or the rolls are moving very slowly.

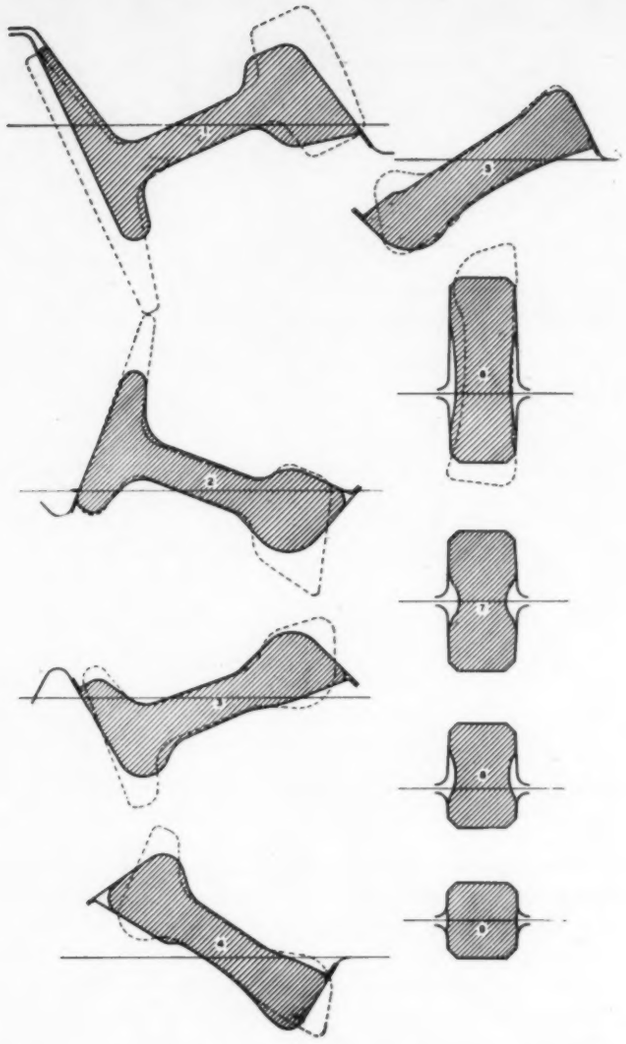
USE OF RAIL BUTTS

A good example of what can be accomplished in roll design by men who have the courage of their convictions is illustrated in the following designs used at the Cleveland Rolling Mill Company about 1869.

The problem was to utilize the vast amount of crop ends on bessemer steel rails which were a drug on the market, because they could not be used to any extent in the steel converters, and most of the plants of the time did not have open hearth furnaces. One of the first ways of utilizing the rail butts was to slit them into



Drawing 43 — Rails were also rolled into rod billets without slitting from 1869 to 1881.



Drawing 44 — Another method of rolling rail into rod billets.

three pieces as shown in Drawing 42 and roll the web into rods after reheating. Then in an 18 in. three-high mill, the head was heated and rolled into a $1\frac{1}{8}$ in. rod billet and the base was rolled into $1\frac{3}{8} \times \frac{7}{8}$ in. rod stock and these also were reheated and rolled into rods.

The use of whole rail butts was the next problem to be solved. Roll designers and rolling men of the time said a section such as a bessemer steel tee rail could not be rolled into a billet without laps or seams, but Henry Chisholm, president of the Cleveland Rolling Mill Company, being sure that low costs could be obtained by using whole rail crop ends for rolling rods, was determined to have them rolled into rod billets. He encouraged his men to work on this problem and, though one failure followed another, insisted on more trials until success was achieved.

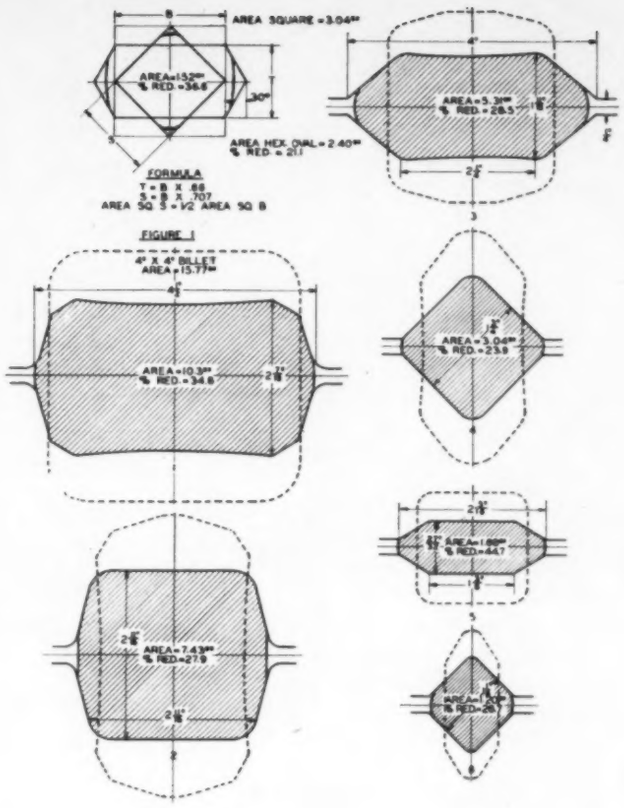
The whole rail was rolled as shown in Drawing 43 into a $1\frac{3}{8} \times \frac{7}{8}$ in. rod billet and for 12 years, from 1869 to 1881, it became a source of cheap billets for rods, and in addition the rods were drawn into spring wire of fine quality. The reduction of the rail butt was done on an 18 in. three-high stand of rolls which was operated by the same engine that drove the rod mill. On Drawing 44 is shown a later design for producing the rod billet from a rail used in another plant. This design features the diagonal method of reduction.

FLAT OVALS

Mention has been made of the hexagon oval. An old formula given for the design of these so-called hexagon-oval passes is shown on Drawing 45, Figure 1. By the formula shown there is a 50 per cent reduction in area from square to square. As previously mentioned, this hexagon shaped pass is hard to fill and, using this formula, fills about as shown on the sketch.

In Figure 2 is shown a roll pass design, partly of this kind, which was used for the roughing passes of a Garrett type rod mill. The roughing was a single-stand three-high 18 in. set, using a 4 × 4 in. billet. Note that the reduction required to fill the passes is considerably in excess of 50 per cent from square to square, and that the square entering the first hexagon-oval pass is given a reduction of 34.8 per cent and the reduction in area from this square to the next one is 59 per cent plus.

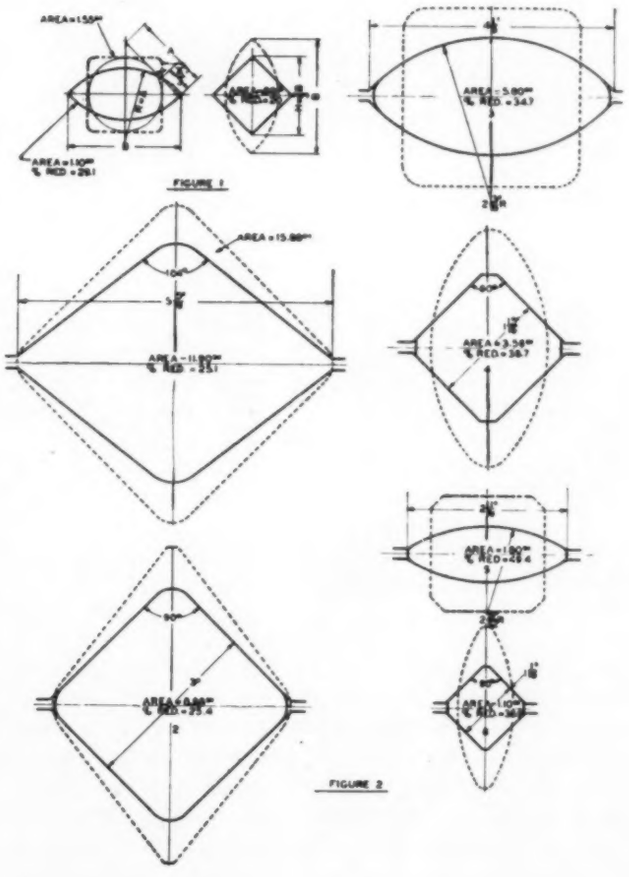
In Drawing 46, Figure 1, is shown an old German formula for square-oval-square reduction. In this de-

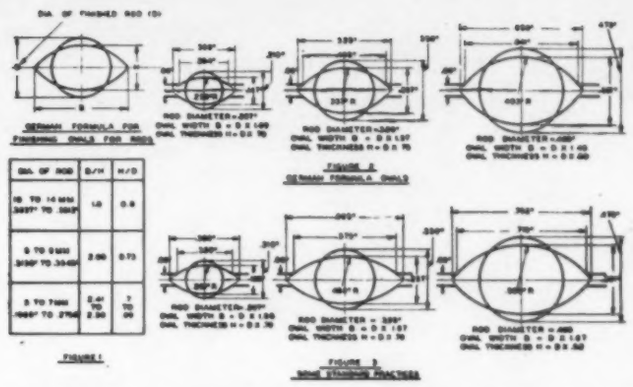


Drawing 45 — Hexagon oval roughing passes for Garrett type mill.

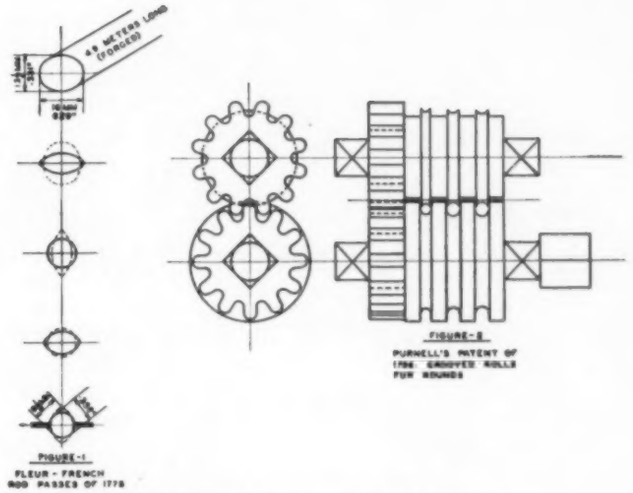
▲

Drawing 46 — Diamond oval square passes for Garrett rod mill.





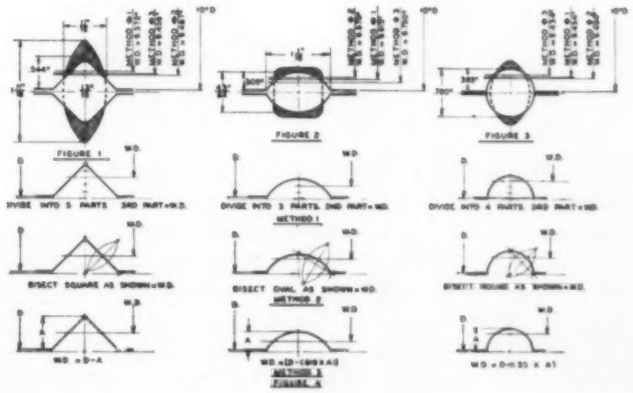
Drawing 47 — Comparison of old German formula for finishing ovals with some modern practices.

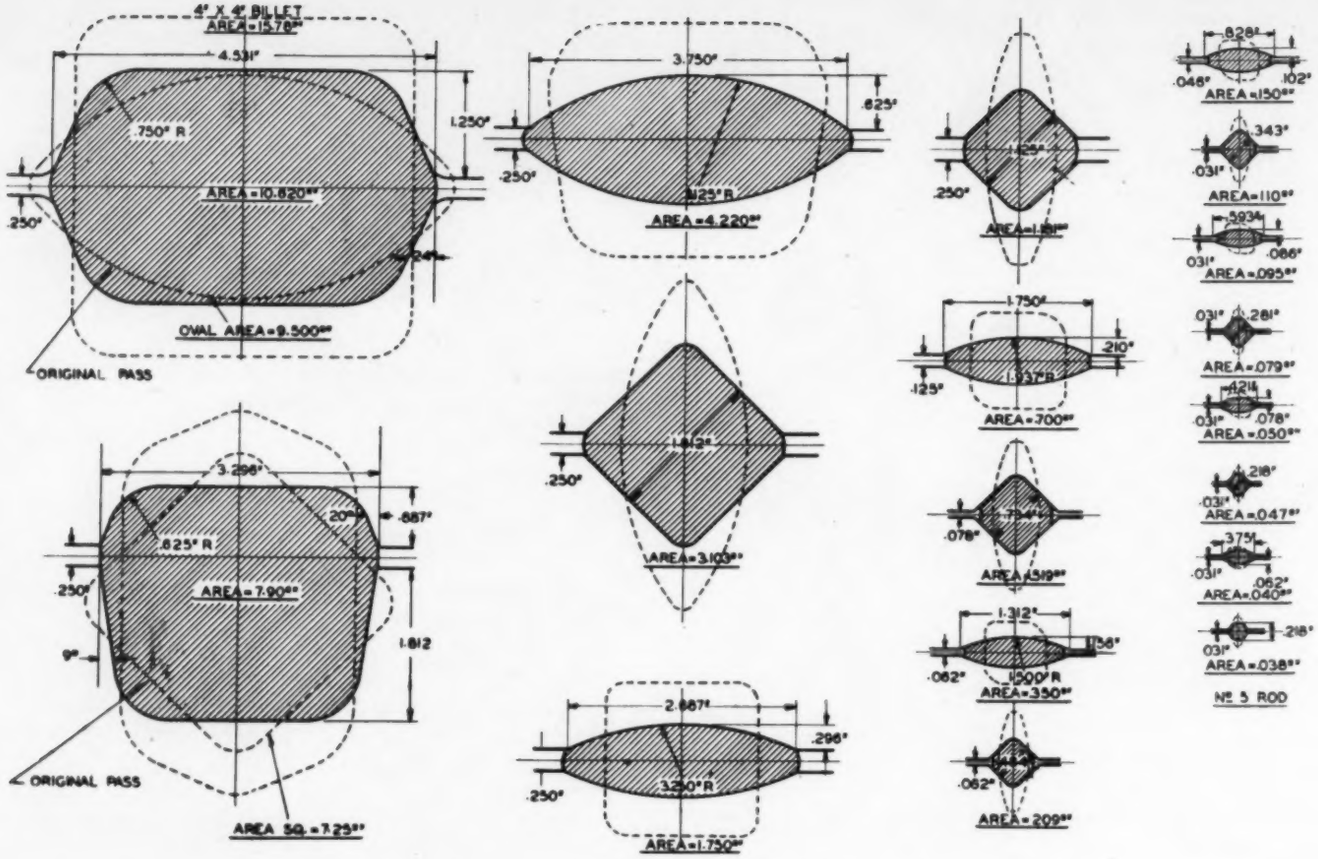


Drawing 48 — Early rod rolling practices.

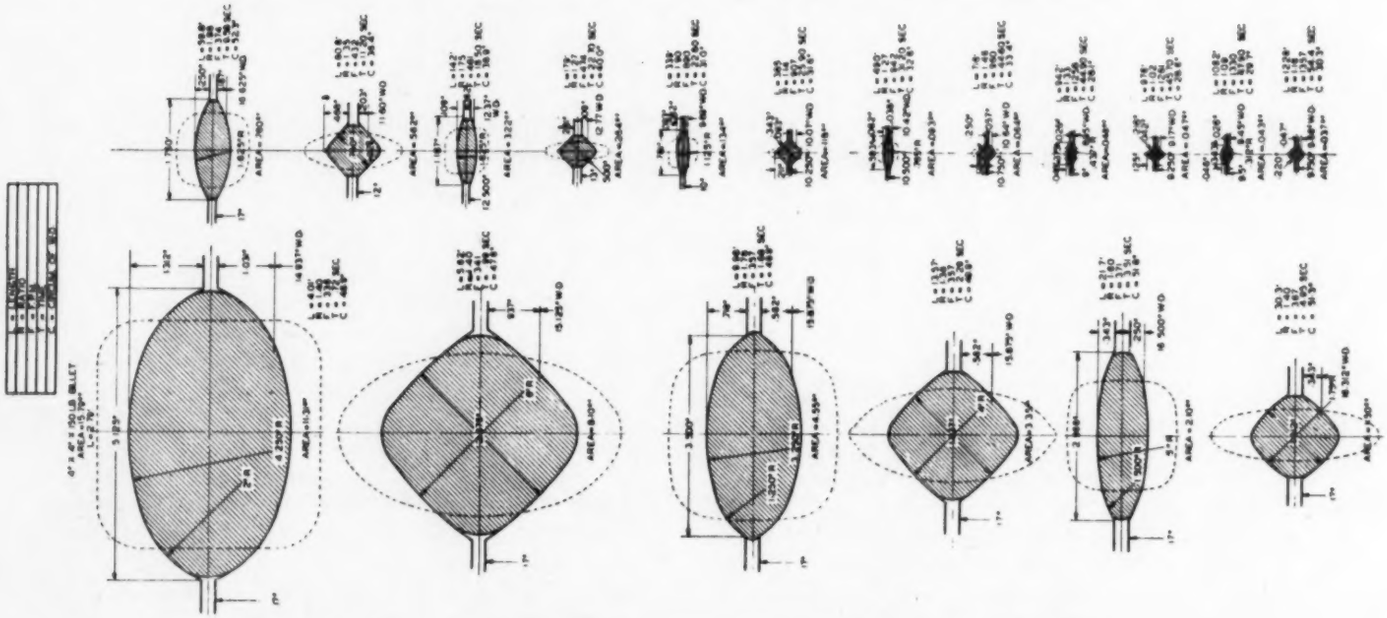
▲

Drawing 49 — Several methods for finding the working diameter.





Drawing 50 — The original Garrett mill pass design was patented in 1882.



Drawing 51 — Oval gothic roughing passes for Garrett mill, patented in 1885.

sign there is also a figured 50 per cent reduction from square to square. Here also the formula does not correspond to actual practice, as may be seen by looking at Figure 2 where a series of roughing passes for a Garrett type three-high roughing mill for rods is shown. Note the reductions.

One Drawing 47, Figure 1, is shown a German formula for finishing ovals for rods. Figure 2 shows examples of this formula as drawn. Contrasted with these, Figure 3 shows some ovals drawn according to modern practice and which are somewhat different from the old German practice. These examples are given to show the doubtful value of formulas in roll designing. A design which might be right for one application, would be wrong for another. Correctly designed passes are developed only by experience.

The French rolling mill man Fleur, previously mentioned, wrote of his work in a French encyclopedia in 1778, mentioning his wire rod mill which reduced an oval 0.531 in. thick by 0.629 in. wide to a 0.354 in. rod in four passes. See Drawing 48, Figure 1. From the description it would appear that the rolls were turned similarly to the round rolls patented by John Purnell in 1766.

Purnell's patent shows a tongue and groove pass arrangement, see Drawing 48, Figure 2. Probably he owed his idea to a study of the slitting rolls used to split plates into rod stock.

WORKING DIAMETERS

One of the most difficult problems which confronted Mr. Bedson when working on the continuous rod mill was to obtain the proper speeds on his mill. Previously on the straightaway and looping mills, the elongation of the bars in the various passes caused no particular trouble, as a variation in elongation due to drafting in the straightaway was no problem and in the looping mill any difference was taken care of in the loops. In the continuous mill, elongation is a real problem and Mr. Bedson found this out to his sorrow. Pull between passes tore the brittle iron and push caused cobbles due to loops forming between passes.

In order to obtain the necessary information on elongation, passes were prepared in an ordinary straightaway mill and the length of the bar after each pass was measured. By this means, the elongation from pass to pass was obtained and the continuous mill geared for increasing speeds to suit the elongation. But one factor was overlooked and that was the so-called working diameter of each roll pass, i.e, between the collar and smallest diameter of the roll passes. No doubt this was a puzzle to Mr. Bedson, and he had to change either roll diameter or number of teeth in the gears or both before getting roll speeds which took care of the elongation correctly. Referring to Drawing 49, Figures 1, 2, 3, and 4, you will note that the working diameter as indicated on the square and oval and round passes is neither the collar diameter nor the bottom of the pass diameter. One of the early rules which was passed around among the rollers and roll designers was that the smallest diameter of a pass governed the delivery speed. This is not true. Somewhere between the collar diameter and the bottom of the pass is a diameter which approximates the actual diameter at which fpm speed of the pass can be figured. This diameter must be selected so that it will take into consideration another factor which influences the fpm speed, namely, extrusion, or faster delivery speed of the bar than the roll. In a light draft, extrusion is not a very serious factor, but in a heavy draft, extrusion adds considerably to the delivery speed. Roll diameter also enters into extrusion, as the contact angle of the bar affects the extrusion. A larger roll diameter for a given reduction means less extrusion while a small diameter means more.

Still another condition which makes it practically impossible to determine the exact delivery speed of a pass is where pull exists in a continuous mill. Such a condition is bound to have an influence on delivery speed. On Drawing 49, Figure 4 are shown a few formulas which have been developed by various operators to determine delivery speed and there is considerable difference in the formulas. All of these formulas are used by designers, and from these various formulas it will readily be seen that no exact formula has been developed by anyone.

The adjustment of the reduction in area between passes, which is accomplished by raising or lowering of the rolls, is the means whereby the elongation is regulated to suit the roll speeds in the case of fixed roll speeds. This is the reason that each formula is workable. In cases where the continuous stands are driven individually, the roll speed is adjusted to suit the elongation.

In figuring the speeds, pass areas, and rpms in a continuous mill, it is the custom of many roll designers to use a formula in which the area $\times$ working diameter $\times$ rpm of pass No. 1 must equal the area $\times$ working diameter $\times$ rpm of pass No. 2. This figure is called the constant. In this figuring, the working diameter is assumed to be such that the extrusion which takes place in the pass is taken into consideration in fixing the working diameter. This formula is a sort of proportion, three factors of pass No. 1 or pass No. 2 must be known; that is, area, working diameter, and rpm. As the rpm and the pass area is usually set, the problem is usually to find the working diameter. Area $\times$ rpm $\times$ working diameter of pass No. 1 divided by the area $\times$ rpm of pass No. 2 equals the working diameter of pass No. 2.

In explaining continuous mill roll design to laymen it is more clearly understood if it is explained that the elongation of the bars in relation to the reduction accomplished must be compensated for by an increasing roll speed from pass to pass. Dividing the area of pass No. 1 by the area of pass No. 2 will give the ratio of elongation. Extrusion or faster delivery of the bars from the pass than the roll diameter is usually not figured for oval-square passes due to the involved calculations necessary, but is assumed to be not more than 2 or 3 per cent in small passes and the working diameter is set on the high side to take care of this. The feet per minute speed of pass No. 1 is figured by the

$$\text{formula } \frac{\text{working diameter} \times \pi}{12} \times \text{rpm} = \text{fpm.}$$

Multiplying this result by the ratio of elongation gives the fpm speed that stand No. 2 must be to take care of elongation. Should the rpm and the area of stand No. 2 be fixed, then the working diameter must be made to suit, in which case the working diameter for stand No. 2

$$\text{is obtained by the formula } \frac{12 \text{ fpm}}{\pi \times \text{rpm}} = \text{working diameter.}$$

GARRETT MILL ROUGHING PASSES

In Mr. Garrett's rod mills the stand billet was four inches square, and his roughing pass design roughed this billet down to a $1\frac{1}{8}$ in. square in six passes in the first 16 in. or 18 in. three-high set.

On Drawing 50 is shown the pass design for the first Garrett Mill erected in Cleveland in 1882, originally an oval-square design. The first two passes were later

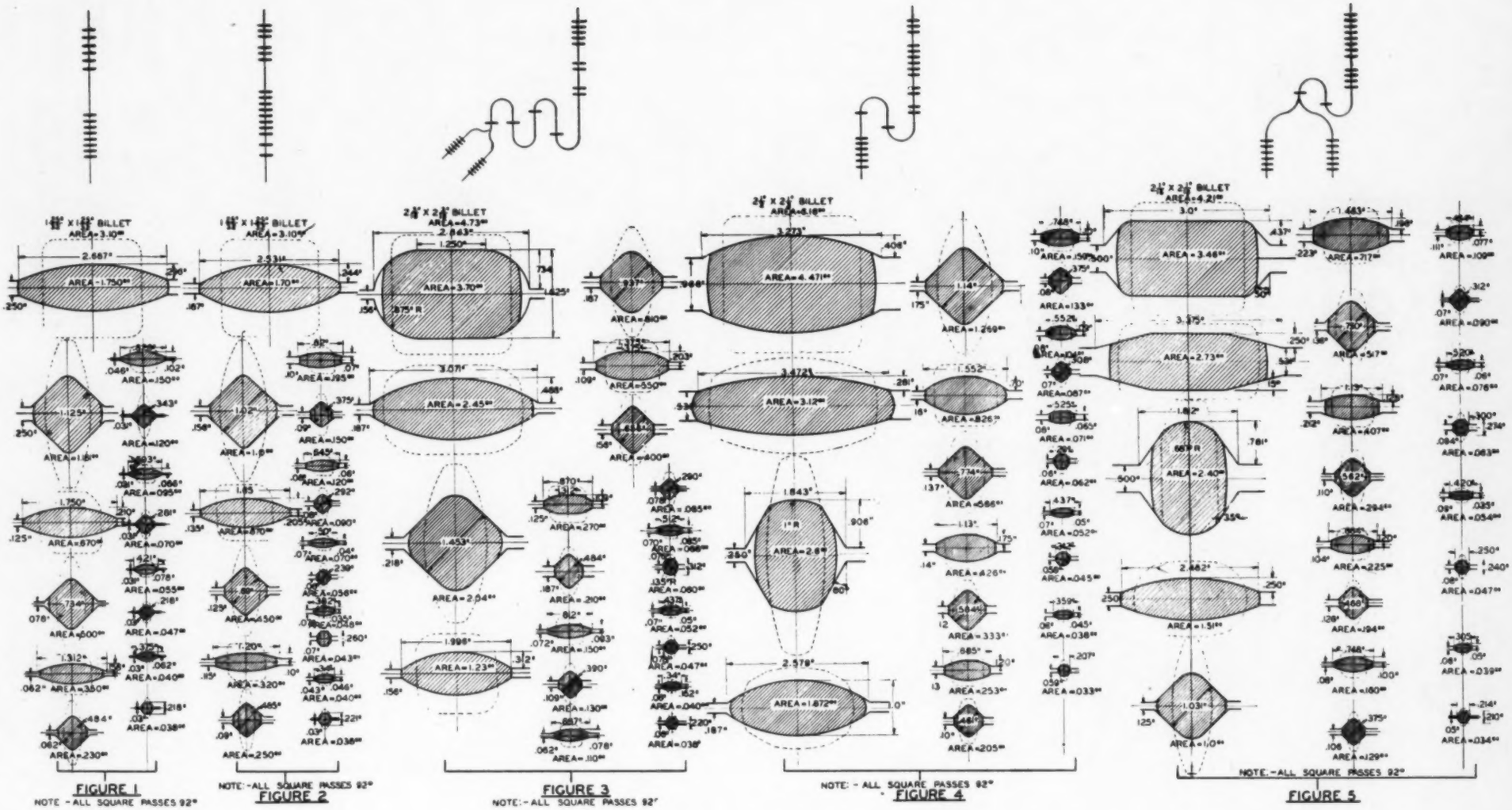


FIGURE 1
NOTE - ALL SQUARE PASSES 92°
FIGURE 2
NOTE: - ALL SQUARE PASSES 92°
FIGURE 3
NOTE: - ALL SQUARE PASSES 92°
FIGURE 4
NOTE: - ALL SQUARE PASSES 92°
FIGURE 5
NOTE. - ALL SQUARE PASSES 92°

Drawing 52 — Various continuous rod mill passes.

changed to a box and edge design, see dotted lines of first and second pass for the original design. The billets as produced on a two-high reversing blooming mill were not perfectly square and the box pass design was better suited to take an irregular shaped billet than either a diamond or an oval. An irregular square will roll in a diamond pass and will lean in an oval while a box pass will square up a diamond shaped billet.

The design shown in Drawing 51 is from a Garrett Mill of 1888 based on the 1885 patent. This mill was erected in Joliet, Illinois, and the billets produced in this mill were rolled on a three-high billet mill which was preceded by a three-high blooming mill. The billets produced were fairly accurate in size and shape, consequently, it was possible to use an oval for the first pass in the rod mill roughing. This Joliet rod mill was an unusually good tonnage mill for rods. Note that in the roughing each oval enters a gothic pass. The oval will stand up easier in a pass of this kind and also the oval will get a more uniform bite on the entering bar.

Drawing 52, Figure 1, shows a fourteen pass rod layout for a straight continuous mill using a 1¾ in. billet. In this design the billet is given a heavy reduction in the first pass.

Figure 2 shows another somewhat similar design of sixteen passes, and in this design a round is substituted for a square in the 14th pass, an innovation to become popular in later mills.

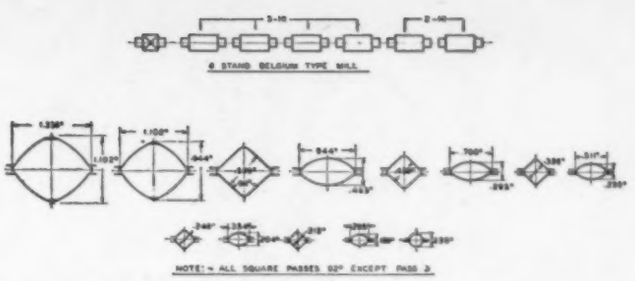
Figure 3 shows a pass design for a mill which rolls both rods and bars. There are nineteen passes reducing the 2⅜ × 2⅜ in. billet to a No. 5 rod. The last six passes are alternate oval and round.

Figure 4 shows a recent rod pass design in which a 2½ × 2½ in. billet may be used. Passes 1, 2, 3, and 4 are so designed that smaller billets may also be used. The result of using smaller billets in the layout is that pass 1 and 2 will be underfilled in the horizontal dimension, but when turned into pass 3 there will be sufficient work to fill the pass to the vertical size, and pass 4 will be filled enough so that the further passes will be the same size as obtained from the 2½ in. billet. This design also features the oval round design in the last six passes.

In Figure 5 is shown a design quite similar to the one shown in the previous figure with pass 1, 2, and 3 drawn somewhat differently as shown. This design takes a 2⅛ × 2⅛ in. billet, but passes 1, 2, and 3 are designed so that 2¼ × 2¼ in. and 2½ × 2½ in. billets may also be used. The other passes are quite similar to those shown in Figure 4.

The passes shown on Drawing 53 are taken from an old book published in 1851 on the European continent. These passes were used on a Belgian type rod train of six roll stands and are as well designed as any modern roll designer could do for the same type mill. The roll drawings are not shown for lack of space, but the position of the grooves in the roll seems to indicate that some looping of the bars was done, although historians claim that looping did not commence until about 1860.

Among the guides used on rod mills, the twist guide is the distinctive one. The twist guide must turn the bars between the continuous stands so that the bar enters in the proper position. Figure 1, Drawing 54, illustrates a twist guide as used on an oval, the oval entering a square.



Drawing 53 — These European passes for 0.220 in. rod were developed prior to 1851.

The oval must be twisted 90 degrees as it comes from the rolls in order to be in position to enter a square. In figuring the twist required in the guide, the distance between the roll stands must be known. The length of the guide bears a definite relation to the distance between centers of the roll stands. The bar, once it has started to twist, will keep on after leaving the twist guide until it enters the succeeding pass. The entry guides of that pass hold the bar from further twisting, also in an upright position.

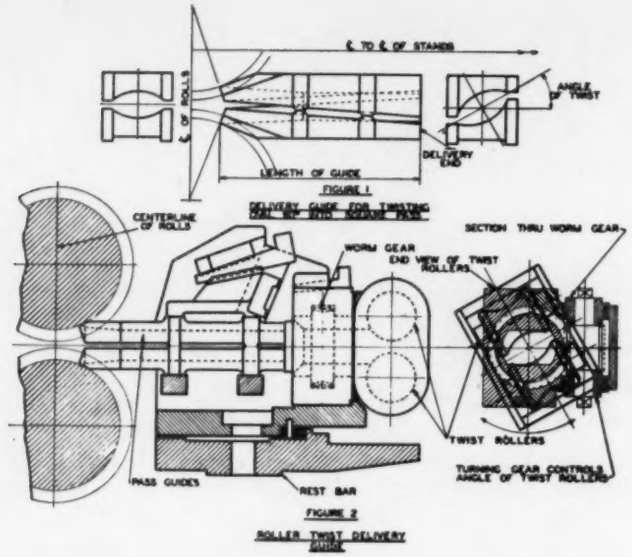
The length of the guide is proportional to the distance from the receiving end of the guide to the next roll stand. This figure divided into this distance, and the result divided into 90 degrees will give the angle of twist the guide needs at the delivering end. Figure 2 on this drawing shows a roller twist guide on which the bar may be given more or less twist as desired by altering the angle of the rollers.

Rod mill roll analysis is in general much the same as for bar mills. Some mills use chill iron rolls for the roughing, particularly when the roughing is continuous. Some prefer "grain" rolls for the roughing. These can be made harder than the chill rolls and usually wear well. The rolls become progressively harder as they near the finishing stand until finally they become as hard as roll turning tools can cut.

Drawing 55, Figure 1, shows a roll mold for a special type of finishing roll used on the final stands of continuous or partly continuous rod mills. The analysis of this roll is carbon 3.15, manganese 0.26, silicon 0.65, sulphur 0.07, phosphorus 0.25, chromium 0.35, nickel 2.60, and molybdenum 0.20 per cent. The Shore hardness of the rolls is around 70 and the chill depth one inch. This roll is a special type of nickel chill and though hard to turn gives good wear.

Roll turning on rod mill rolls is pretty much the same as for bar mill rolls in the roughing stands, but in the finishing stands there are so many passes of the same size that a roll with 25 passes and a 10 in. diameter requires about 15 hours roll turning time per roll when using a single tool as illustrated in Figure 2, Drawing 55. Some rod mill roll shops use a gang tool such as is illustrated in Figure 3. This tool turns fourteen passes at once at a vast saving in time and cost.

The passes for continuous rod mills are almost invariably designed oval and square down to the finishing round pass. In some designs two ovals are used as passes one and two. In these layouts the first oval takes a light reduction for two reasons; one is that as the billet is shoved out of the furnace and the pinch rolls take hold, it is desirable for the billet to enter the rolls without



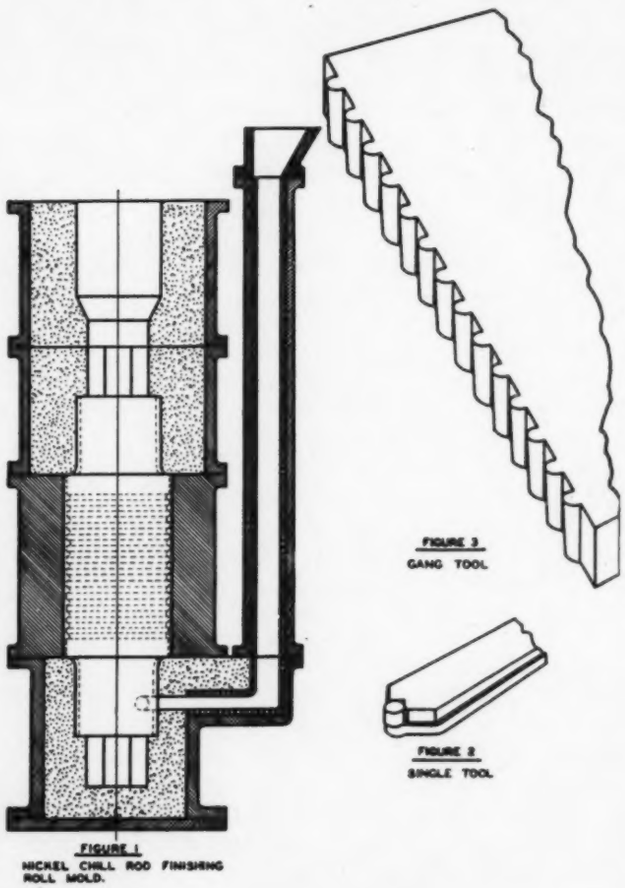
Drawing 54 — Twist guides used on rod mills.

any hesitation and if a heavy reduction was taken the piece often would not enter readily. The light hold of the first pass will be sufficient to force the bar into the second and heavy draft pass. The second reason is that some scale is expected to drop off in the first pass. In some designs a box groove is used for the first pass, also a slight forming of the oval in the first pass tends to prevent the bar ends from spreading excessively.

Referring back to Drawing 52 wherein some continuous and continuous-looping rod pass designs are shown you will note the sketches above the passes indicate the type of mill on which the passes are used. it will also be noted that a number of the designs show the use of the round-oval, round passes. Twisting bars in close coupled mills is the cause of considerable trouble at times. Bars are scratched by close fitting guides and, if the passes are not filled properly, there is a tendency for the underfilled and overfilled squares to lean over in the oval passes and cause irregularities in the rods. The round is as a general rule more uniform in section and will fill the oval more evenly and does not require twist guides for entrance to the oval. There is little loss of draft by this method.

The rod mills have been gradually developed from the simple early hand mills where the skillful use of the tongs by the operators made the rolling of the small, quickly chilled rods possible, to the mechanized mills where the use of tongs has been eliminated. It is believed that no other branch of rolling can show as much progress as has been made. Starting with an initial tonnage of three tons per turn slightly over 100 years ago, a modern mill can now roll 50 tons per hour of No. 5 rod or 400 tons per turn, an increase of over 133 times the original tonnage.

Drawing 55 — Roll mold and roll turning tools.



Other papers by Ross E. Beynon which have appeared in the IRON AND STEEL ENGINEER are as follows:

†Bar Mills and Bar Mill Roll Design.....December, 1943, Page 40; Annual Proceedings, Page 628

†The Rolling of Semi-Finished Steel.....August, 1944, Page 37; Annual Proceedings, Page 427

*Structural Mills and Structural Roll Designing.....February, 1945, Page 35; Annual Proceedings, Page 87

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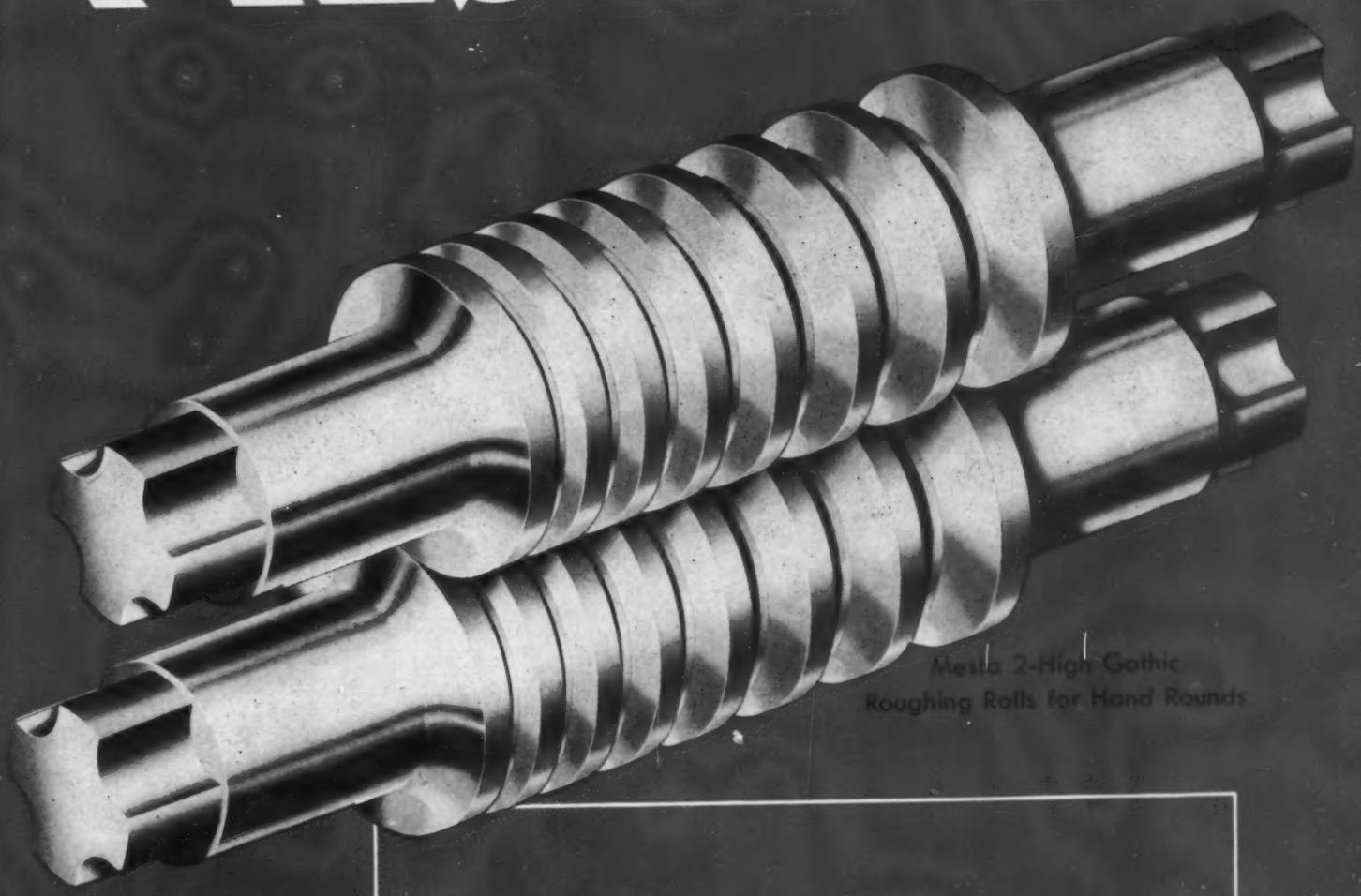

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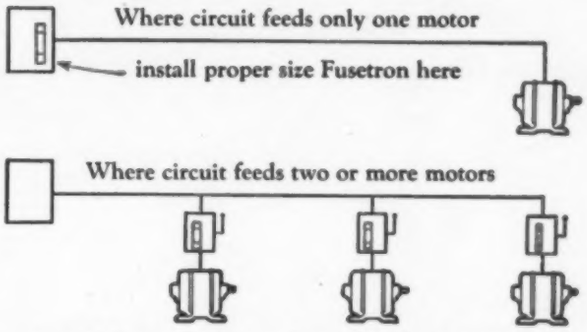

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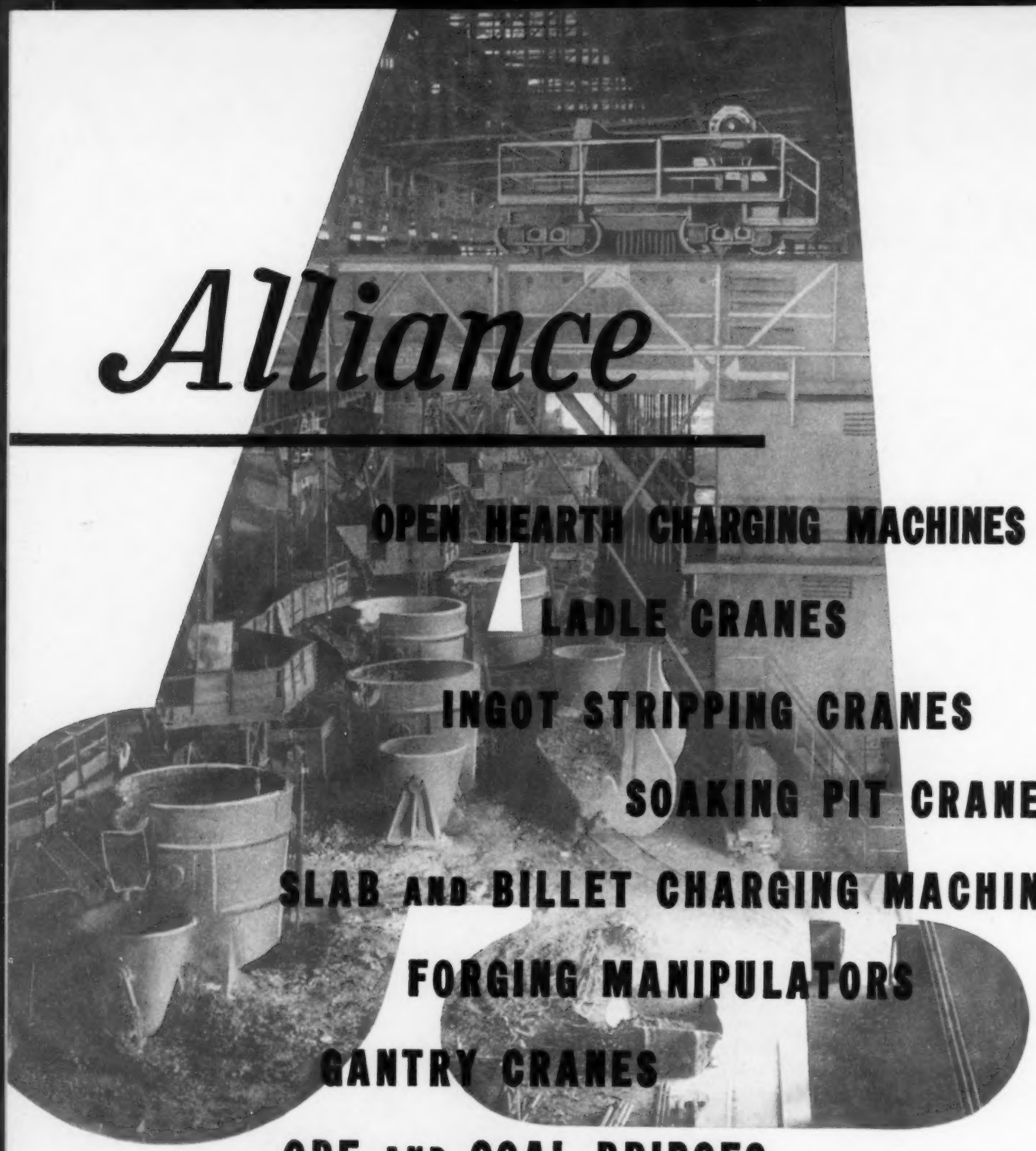

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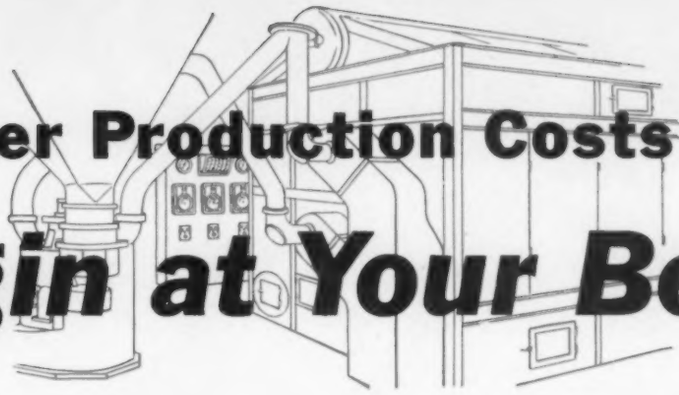

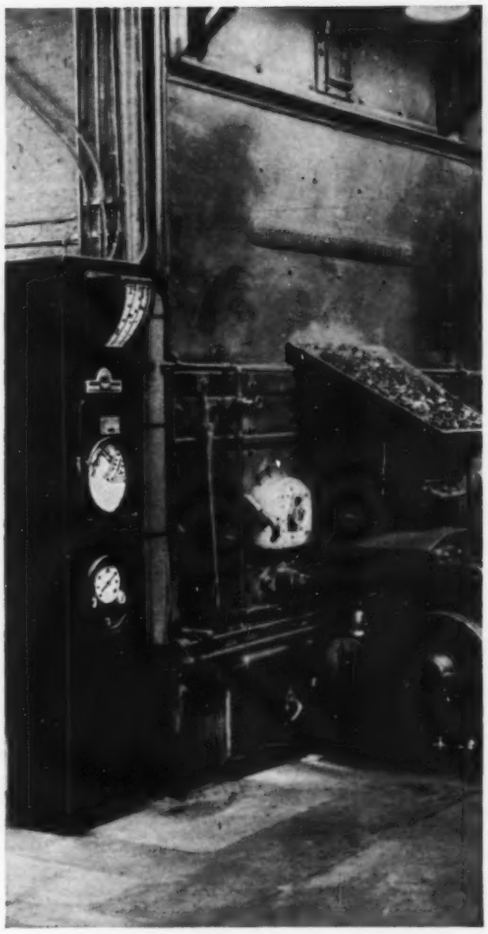

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There is a quick, easy way to convince yourself that co-ordinated boiler control will be profitable to you. Ask a Bailey Engineer to arrange a visit to a nearby Bailey Installation. We invite your inspection.

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Controls FOR STEAM PLANTS

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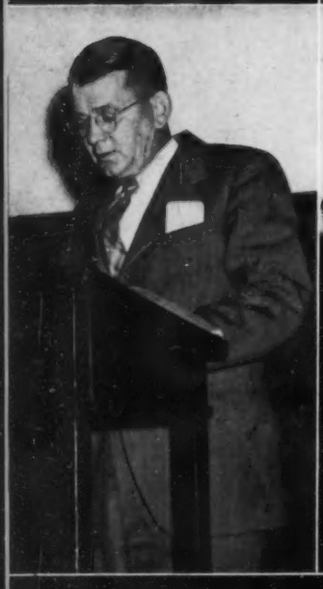

The 1947 annual spring conference of the Association of Iron and Steel Engineers was held in Philadelphia, Pennsylvania, on May 26 and 27. Registration, conducted in the foyer of the Benjamin Franklin Hotel (above, left), totaled over 500 members and guests. The meetings were held in the Crystal Ball Room and Betsy Ross Room of the hotel. Among the authors presenting papers were (left to right, upper center, downward from registration picture): William L. Stover, Mesta Machine Company, and E. Crankshaw, Cleveland Graphite Bronze Company; (lower center) C. E. Duffy, Bethlehem Steel Company, and R. F. Lavette, Republic Steel Corporation. Bottom left shows W. A. Ashton and Robert N. Merk, Carnegie-Illinois Steel Corporation. Representative of the industry-wide attendance are shown left to right at top of this column R. C. Jordan, Selas Corporation of America; A. J. Fisher, W. E. Grainger, and L. F. Coffin all of Bethlehem Steel Company, and immediately above are shown C. S. Carlson, American Steel and Wire Company; L. Moses, Bethlehem Steel Company; O. P. Ashurst, Giffels and Vallet, Inc., newly appointed AISE Detroit district section secretary; Linn O. Morrow, secretary of the Philadelphia district section; and B. Hambleton, Ohio Electric Manufacturing Company.

PICTORIAL REVIEW OF THE AISE

Monday evening, May 26, a reception for the dinner speaker, R. W. Wolcott, president of Lukens Steel Company, was held. Among the reception guests shown in picture at top of this column were L. T. Barry, Electric Service Manufacturing Company; George H. Schaeffer, past AISE president for 1926; and John C. Reed, past AISE president for 1909 and a charter member. Immediately above are shown Freeman H. Dyke, Wheeling Steel Corporation, past AISE president for 1946; L. F. Coffin, Bethlehem Steel Company, past AISE president for 1938; and J. M. Entwisle, vice president of operations, Henry Disston and Sons, Inc. Shown at top of right hand column are J. M. Sylvester, general manager of the Bethlehem plant, Bethlehem Steel Company; R. W. Wolcott, Lukens Steel Company; and L. R. Milburn, Great Lakes Steel Corporation, AISE president for 1947.

Tuesday, May 27, an inspection trip (right, upper center) was conducted through Lukens Steel Company, Coatesville, Pennsylvania. Lukens was host at a luncheon (right, lower center) served in the Coatesville West End fire department building at noon. Following the luncheon, addresses of welcome were delivered by G. D. Spackman, vice president of operations, and Walter H. Burr, of the Lukens Steel Company, shown in picture at bottom of column.

. . . 1947 SPRING CONFERENCE

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Individualized Roll Service

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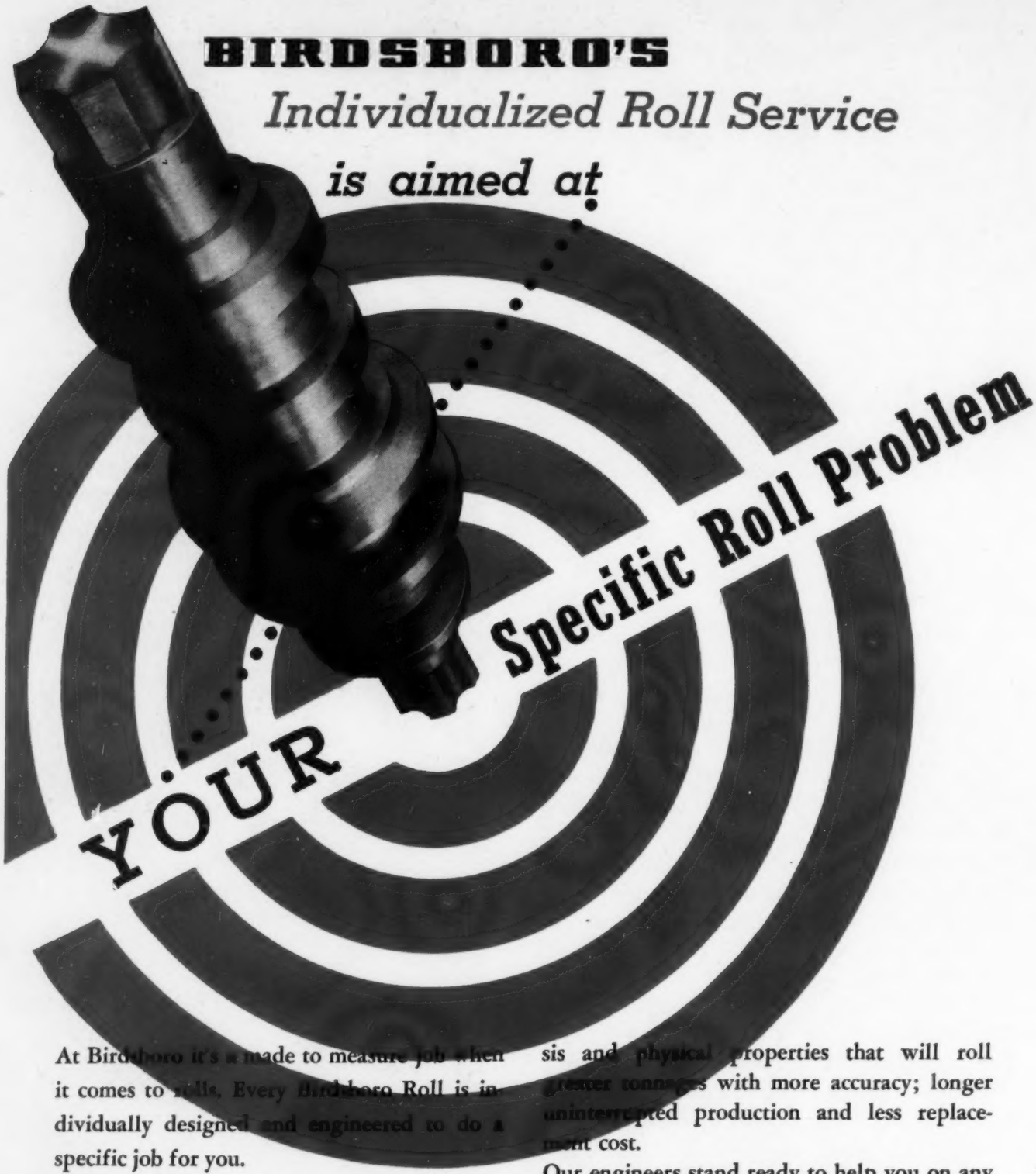

At Birdsboro it's a made to measure job when it comes to rolls. Every Birdsboro Roll is individually designed and engineered to do a specific job for you.

Because they are made to your specifications, you can expect a combination of correct analysis and physical properties that will roll greater tonnages with more accuracy; longer uninterrupted production and less replacement cost.

Our engineers stand ready to help you on any problem involving long range rolling efficiency and economy. Write us today.

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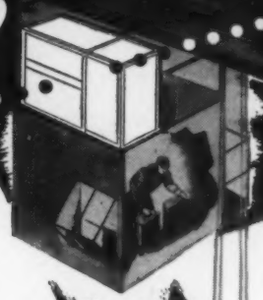
ROLLS

CRANE CAB COOLING



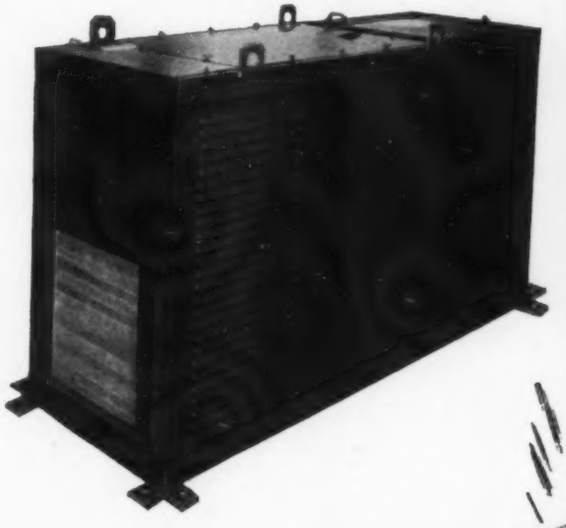
MEMO TO:
OPERATIONS DEPT.

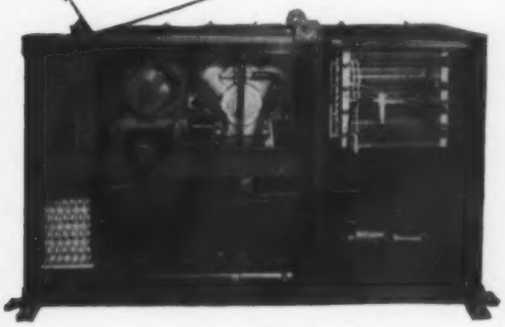
Wherever your hot metal crane operations involve working in excessive heat, obnoxious fumes, annoying odors, or dust, you can eliminate these hazards with **DRAVO CRANE CAB COOLERS.**

MEMO TO:
MAINTENANCE DEPT.

DRAVO CRANE CAB COOLERS are designed for mill duty under the most severe conditions.

Dravo Engineers have given long study to the maintenance problem and to the arrangement of equipment so that it is quickly accessible.





All panels are removable without tools. Moving parts and control panels are completely protected by the rigid frame.

These completely self-contained units provide clean, cooled, dehumified, decontaminated air to the crane cab in sufficient volume for any hot metal crane requirements.

DRAVO CRANE CAB COOLERS can be shipped from stock for use this summer. Each Dravo Crane Cab Cooler is equipped with units for winter heating as well as air conditioning.

DRAVO CRANE CAB COOLERS will operate safely, efficiently, and with minimum repairs, provided they receive the same periodic maintenance given to other electrical and mechanical equipment.

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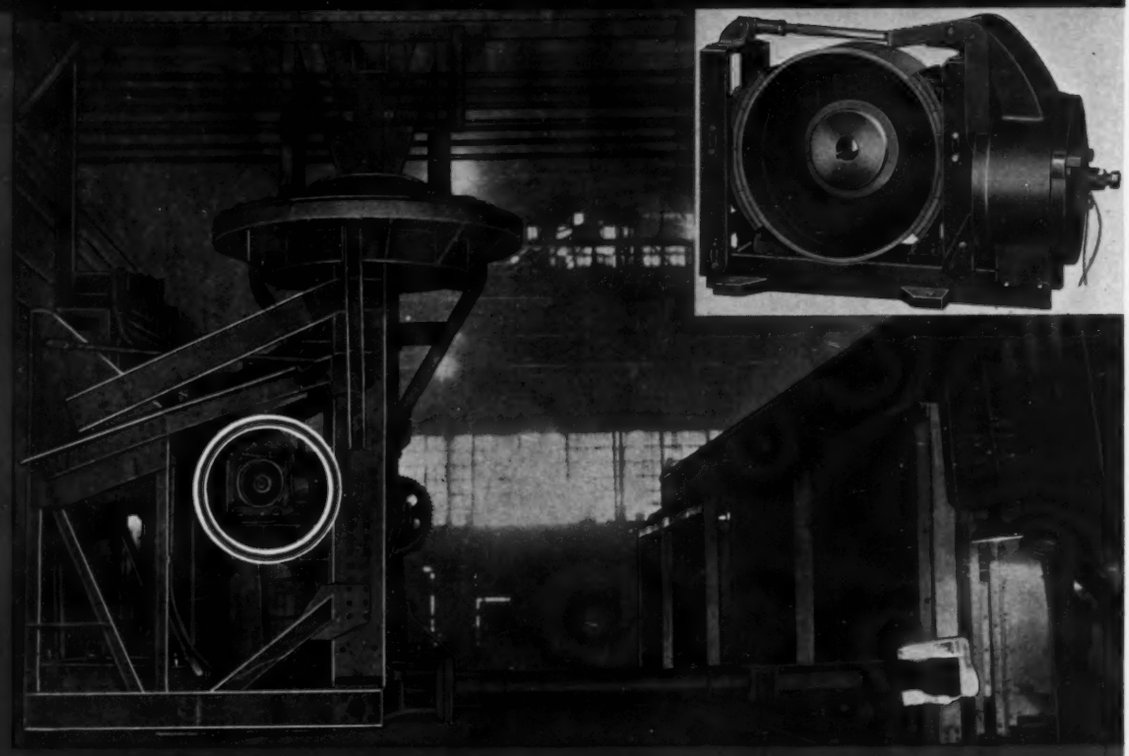
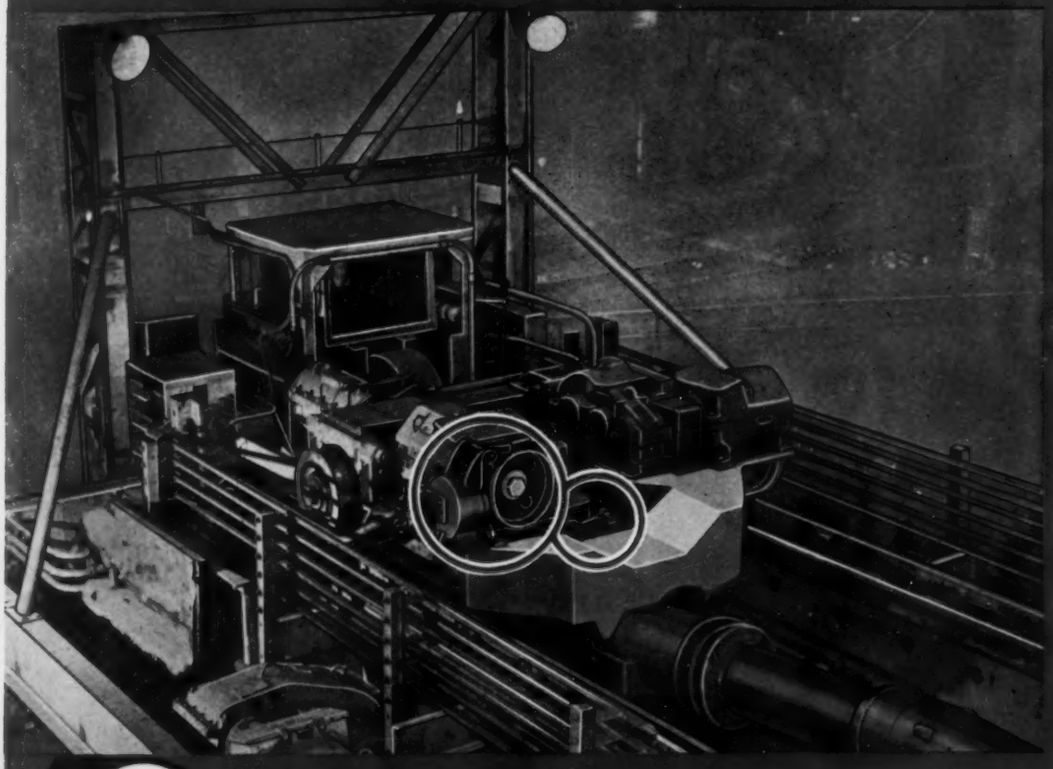
Where the going is toughest . . .



Above:
OVERHEAD WHEEL CHARGER
(Inset shows Clark Bulletin 106 D. C. Shoe Brake)



Left:
OPEN HEARTH CHARGING CAR

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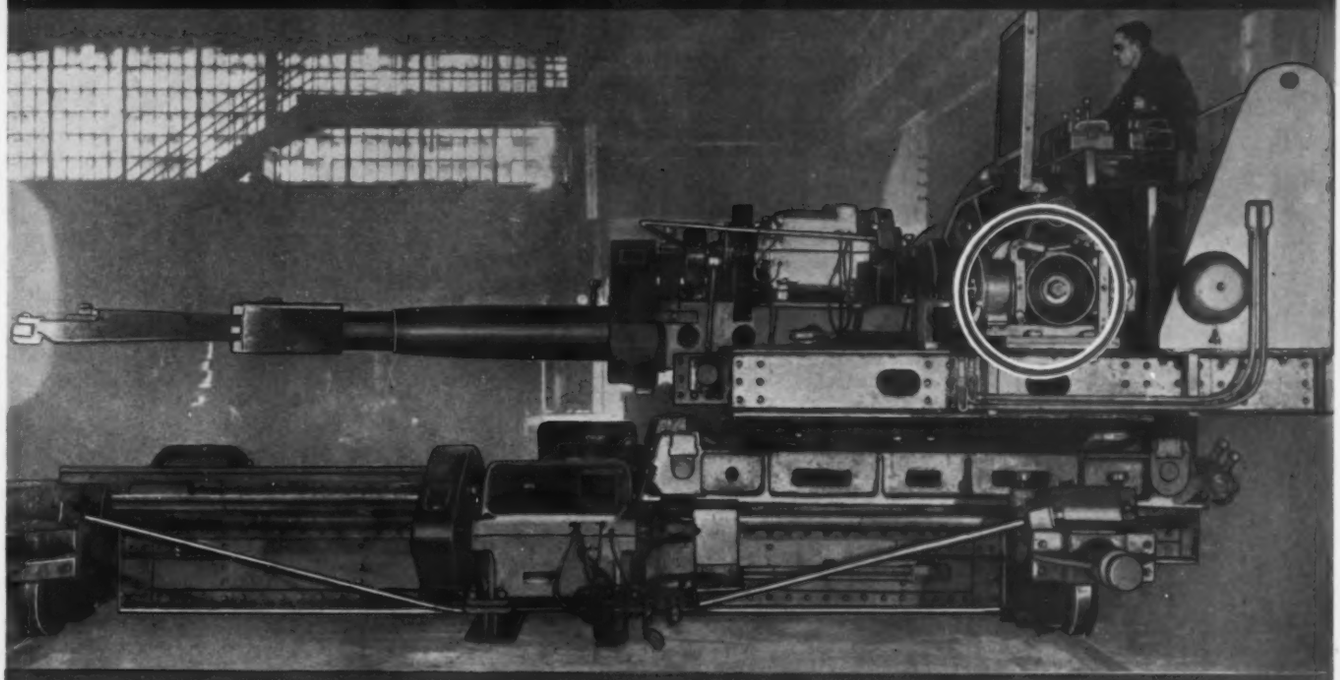
EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO

use CLARK Bulletin 106 D.C. SHOE BRAKES



FLOOR TYPE WHEEL CHARGER

Pictured on these pages are three of the toughest heavy duty braking jobs in the Steel Industry. Hair trigger response, and immediate, smooth, positive braking action without severe shock to connected mechanisms are required 24 hours a day.

Clark Bulletin 106 D.C. Shoe Brakes answer these demands. Sturdy, all-steel welded fabricated construction provides the necessary strength for gruelling heavy duty service. They're simple to install—and only ONE maintenance adjustment—that's for lining wear—is necessary.

You can see at a glance—DURING OPERATION OR WHEN THE BRAKE IS IDLE when lining wear makes adjustment necessary. And you just look at the TOP of the brake—not at the bottom—not at the ends—not at the sides—but on TOP—where the entire adjustment is made—where you can see what you're doing and can get at it easily.

Shoes can't tip—shoe drag is automatically eliminated by a simple tamper-proof patented device.

Our nearest District Office or Agency will gladly give you full details. Ask for Descriptive Bulletin 106.

CLARK BULLETIN 106 D. C. SHOE BRAKES are designed to fit the new 600 series line of Mill Type Motors. Thus, whether you have old or new type motors, Clark Bulletin 106 D. C. Brakes are applicable.

EVERYTHING UNDER CONTROL

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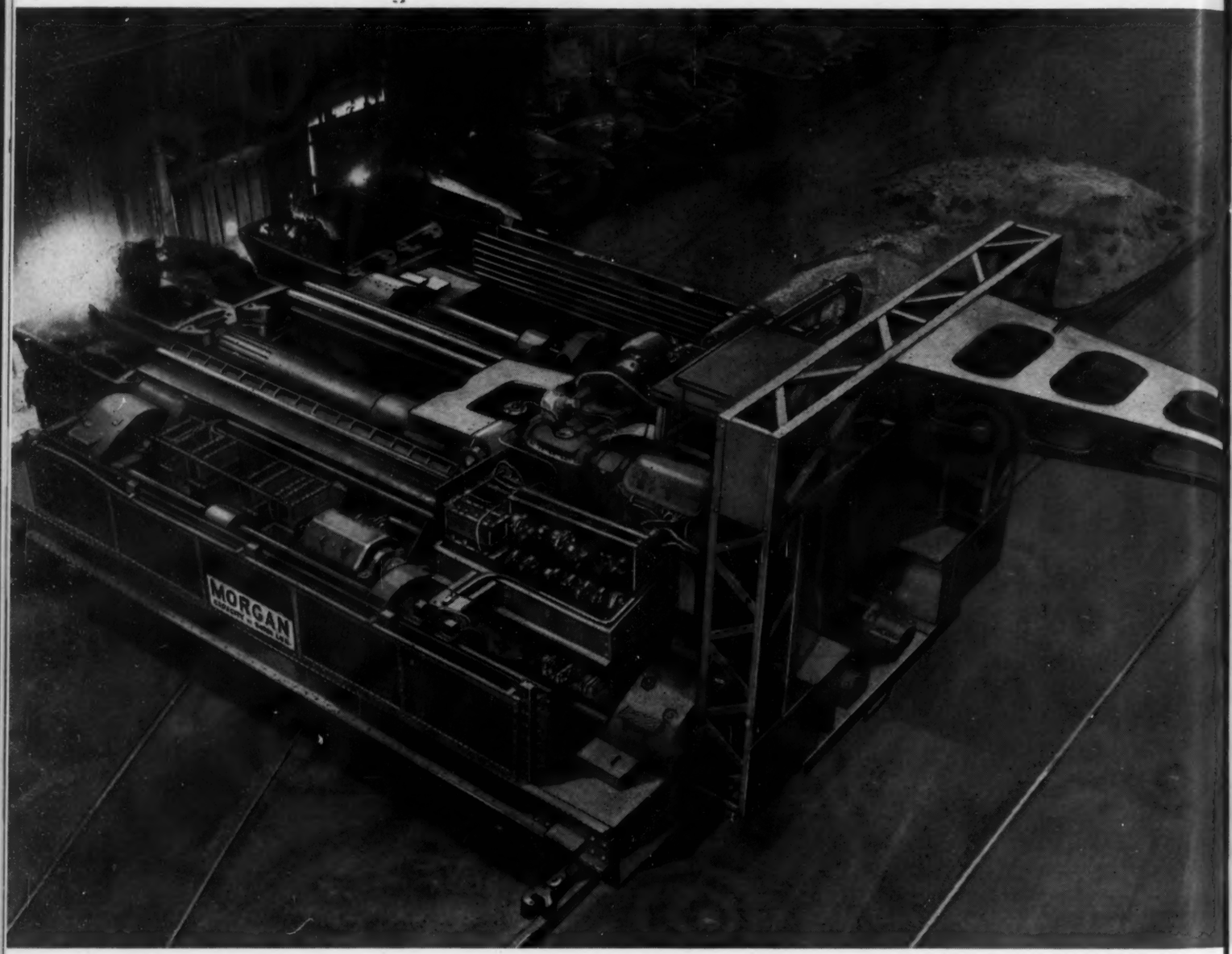
BUILT BY MORGAN Engineering

MORGAN 12-TON LOW TYPE OPEN HEARTH FLOOR CHARGER



Illustrated is one of three Morgan 12-ton 27'-0" span Box Chargers on this open hearth floor. Trolley frame is a one piece steel casting. Girders are of heavy box section. End carriages are of fabricated welded box construction. Roller bearings are used throughout. Entire machine is of massive construction especially designed for taking heavy thrust loads. Morgan Chargers are built in a wide variety of sizes in both the low and high type to meet varied charging floor requirements.

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ALLIANCE, OHIO. 1420 Oliver Building, Pittsburgh

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NEWS SUPPLEMENT JUNE, 1947

Equipment
Personnel
Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

NATIONAL TUBE COMPANY PROJECT MAY REVOLUTIONIZE GAS STORAGE METHODS

▲ National Tube Company, a U. S. Steel subsidiary, is collaborating with the Public Service Company of Northern Illinois in a project experts believe will revolutionize the natural gas storage field. In short, the project provides for gas storage underground rather than in the conventional storage tanks above ground, and insures larger subterranean natural gas storage facilities in the years to come.

Last fall the utility completed a pilot installation of subterranean gas storage at Kankakee, Illinois, and will start this week on an installation on a 160-acre tract at Wolf and Foundry Roads at Mount Prospect, Illinois, nearly forty times as large as the Kankakee pilot installation. National Tube built the high pressure torpedo-like steel pipe sections for the Kankakee project and is now furnishing the underground pipe for the Mount Prospect installation.

At Kankakee the pilot plant has a capacity of 1,250,000 cubic feet of gas, while at Mount Prospect the finished project will have a capacity of 40,000,000 cubic feet.

Since there were no previous installations of this kind to guide them, engineers of the utility company and National Tube pioneered step by step in the development, first in blueprints and then by experimentation. When preliminary tests of pipe installation had been completed, construction of the pilot plant at Kankakee proceeded according to schedule.

Finally, with the Kankakee installation completed, but before actual gas was introduced into the underground storage system, a conclusive test was made with air. The test was successful and natural gas was then forced into the sections under pressure, and the Kankakee plant was in operation. It has been operating successfully since November.

The pipe sections made by National Tube for the underground gas storage program are fashioned from 24-in. seamless molybdenum steel pipe, similar to that used in the "Big Inch," except that the wall thickness is ½ in. as compared with ⅜ in. in the "Big Inch." Each of the completed pipe sections weighs about 5000 lb and is 40 ft long, with a capacity of 25,000 cu ft at 2240 lb pressure. They are nosed in at the ends and machined for connection, one to another.

The pipe sections, covered with a waterproof coating, are buried about 5 feet underground. The utility company reports that underground gas storage primarily has a lower cost of initial installation; and secondly, a lower cost for operating and maintenance than the conventional gas holders so familiar in the American landscape. According to the utility company, another important point in favor of the underground system is that, since storage is in numerous small units, storage capacity may be added easily or any unit may be taken out of service for repair or inspection without disturbing others. Inasmuch

The high-pressure torpedo-like sections are 40 ft long and are fashioned from 24 in. seamless molybdenum steel pipe, each weighing 500 lb with a capacity of 25,000 cu ft at 2240 lb pressure. The sections are waterproofed and buried 5 ft underground.

as the installations are subterranean, above-ground hazards are eliminated.

Pipe for the sections is made and finished at plants of National Tube Company at McKeesport, Pennsylvania. The completed sections undergo hydrostatic water testing to insure that they withstand pressure of 2800 psi.

FRENCH STEEL COMPANIES ORDER WEAN EQUIPMENT

▲ Wean Engineering Company announced the reception of orders from five French leading companies for rolling mill equipment.

These orders have been received through Wean Engineering's French representatives, Documentation et Licences, Paris, and are considered as some of the very first orders placed by the French private steel industry since the liberation of this country.

DIESEL-ELECTRIC ENGINE CUTS OPERATING COSTS

▲ A General Electric 45-ton, 300-hp diesel-electric locomotive, replacing a 90-ton steam engine, is speeding freight car line production for American railroads at the St. Louis plant of the American Car and Foundry Company. Over a period of three years higher line production with greater safety has been realized with this new industrial locomotive.

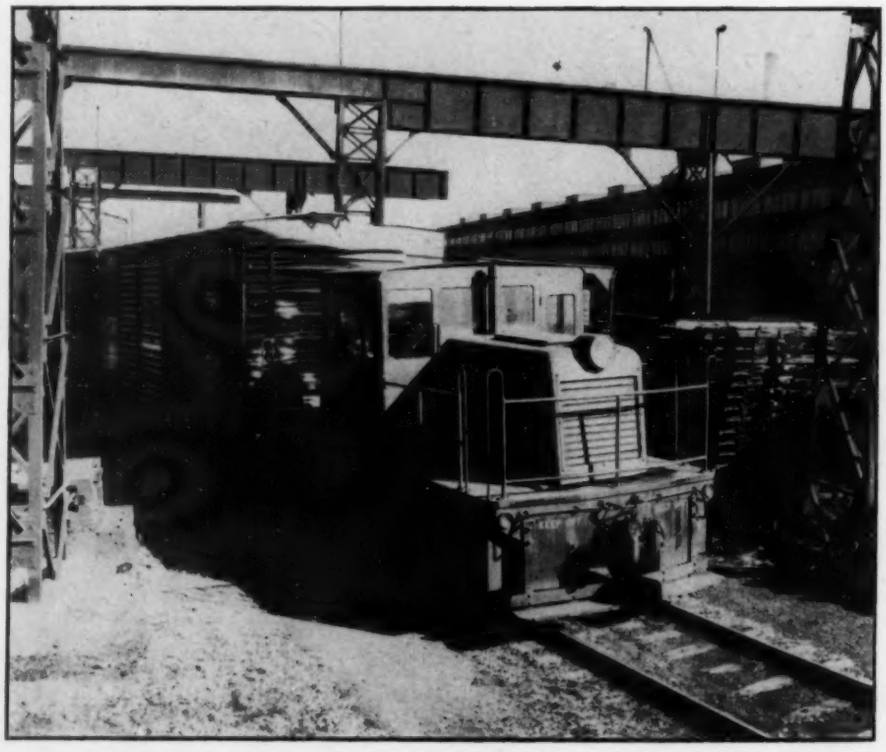
The primary job of this diesel-electric is spotting cars on production lines in various plant building where all types of freight cars are being built. Extreme care is necessary during spotting or production line shifting in order to minimize the danger of injury to production line personnel. Production requires, at times, shifts of only a few inches. The high sensitivity of control on the 45-tonner easily permits this accurate spotting of cars.

The diesel-electric locomotive is also used for general yard switching which includes the transfer of 15 to 20 cars from the final assembly line to a main line railroad outside the plant.

Over a period of three years, this 45-ton locomotive has operated an average of 10 hours a day, six days per week; an approximate total of 9500 operating hours. During this period the locomotive has had an availability for service of more than 95 per cent.

Considerable savings in maintenance and operating costs have resulted through the use of the diesel-electric locomotive. Expenses of a locomotive fireman, hostler and enginehouse rental, necessary with steam locomotive operation, have been eliminated; the diesel-electric is housed in the plant paint shop. Maintenance on the 45-tonner is performed during hours when the locomotive is not in use. The diesel-electric locomotive requires fueling only twice a week whereas the steamer had to be serviced daily.

Operating 10 hours a day for three years, with a 95 per cent service availability, this locomotive has shown considerable savings in maintenance and operating costs.



REBUILT FURNACE NOW HAS 700-TON DAILY CAPACITY

▲ Rebuilt in record-breaking time of 123 days, Duquesne works' old No. 6 blast furnace is making iron again at this Carnegie-Illinois Steel Corporation plant, continuing a 41-year career at the same site where steelmaster Andrew Carnegie operated some of his early furnaces long ago. Normally, the rebuilding of a blast furnace takes a year or longer.

The towering Carnegie-Illinois stack was destined for the scrap pile after a noteworthy career, including iron making for both World Wars; but the postwar demand for steel needed her continued service. Steelmaking requires iron, and old No. 6 was a top-notch producer until she went down.

Her crew took the furnace out of blast October, 1946 due to hearth jacket failure. The big furnace went through World War II without a single halt. The old stack was entirely scrapped and the larger new furnace went up on the original foundation. The complete rebuilding returned old No. 6 to active duty and boosted rated capacity 69 tons, to better than 700 tons a day.

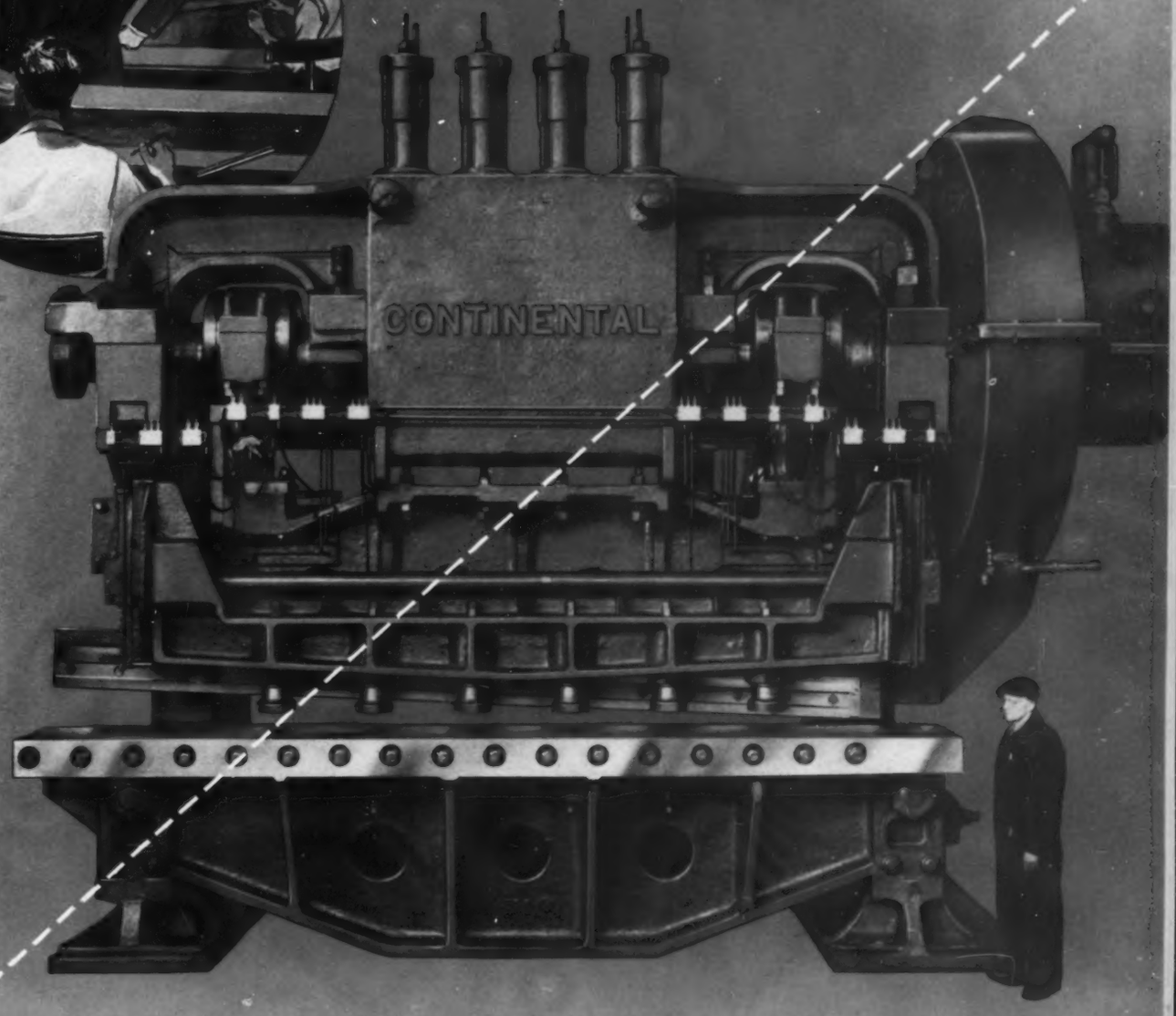
NATIONAL TUBE AWARDS BESSEMER PLANT CONTRACT

▲ National Tube Company has awarded a contract to Pennsylvania Engineering Corporation for the building of a new bessemer plant at Lorain works in Lorain, Ohio. The contract calls for the fabrication and installation of four 25 ton bessemer converters, two 800 ton hot metal mixers, blast piping, transfer cars and auxiliary equipment. The mixers and the converters are of a new improved

(*Please turn to page 117*)

Continental

designs and builds the new Engineering Ideas in



Metal Producing, Metal Handling Machinery and Equipment

Need a special type of equipment,—to do an unusual job,—using a new metal or alloy—for a new product—for lower labor or production costs? CONTINENTAL engineers can provide the experience, knowledge and aid for the successful solution of these problems —*quickly*—let them work with you now.

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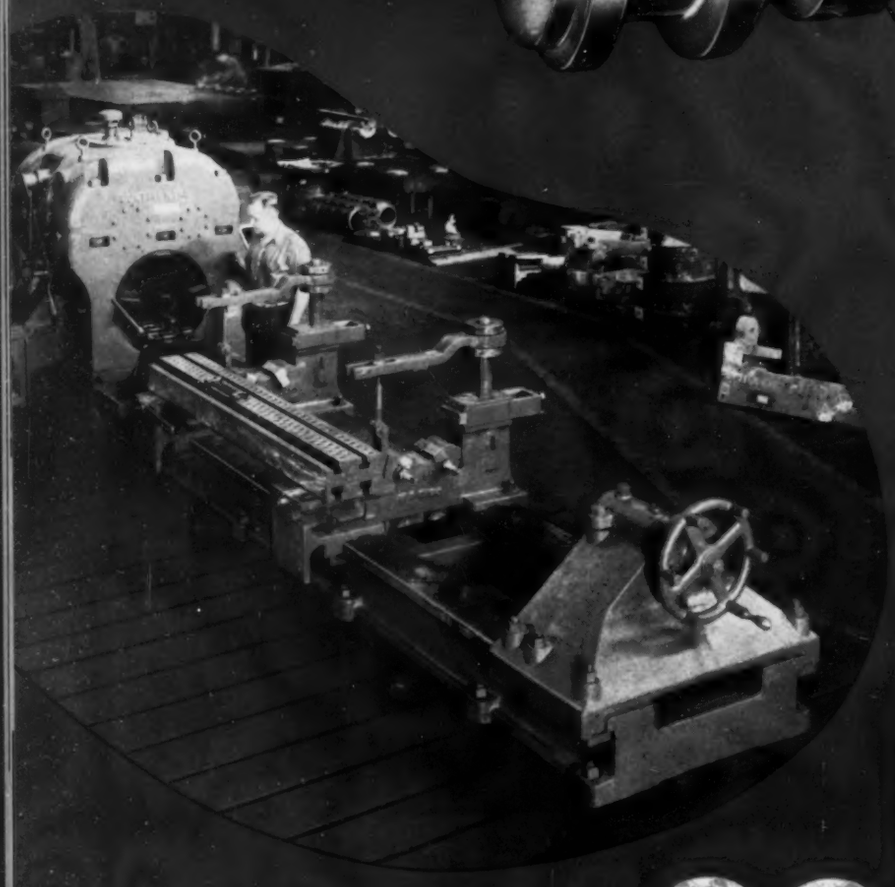
FROM ROLLS TO MILLS



Designs and Builds Dependable Equipment for Progressive Steelmakers

CONTINENTAL—*a single, dependable source* for hot and cold ferrous or non-ferrous rolling mills, the correct rolls, accessories and equipment for low cost operation.

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Plants at: E. Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

(*Continued from page 114*)

design, recently developed by the company's engineers.

In addition to the National Tube Company contract, Pennsylvania Engineering Corporation is building equipment for many other companies, including a new bessemer plant for Great Lakes Steel Corporation, Detroit, Michigan, which includes two 25 ton bessemer converters with all the necessary auxiliary equipment.

Final shipments are being made now on a bessemer converter plant for the Monterrey Steel Company of Mexico and Cia. Acos Especiaias, Itabira, Brazil.

In order to take care of the machining of large pieces of equipment, the company has recently installed a 24 foot diameter boring mill, one of the largest in this district. With orders now upon the books of the Pennsylvania Engineering Corporation, steady operations are assured for the next eighteen months.

POWER UNIT TRIPLES MILL SPEED AT WEIRTON

▲ Motors and electrical control apparatus installed on the world's first mile-a-minute steel rolling mill were individually designed by Westinghouse Electric Corporation engineers to meet the unprecedented speed and control requirement necessary for the mill's operation, according to L. M. Gumm, manager of the company's steel mill section.

The electrically driven power unit, which began operation recently in the Weirton Steel Company plant, drives the mill nearly three times as fast as the majority of strip mills now in operation. The six mill and reel motors are of greater capacity than any previously used in cold strip mill construction as they have a total output of 17,550 horsepower. The 4500 horsepower unit that delivers the finished product from the last stand is the largest ever used on such a project.

Each motor required individual design to coordinate the five sequences of speed necessary for over-all operation of the mill. Steel feeding into the mill passes through the first of five sets of rolls at approximately 650 feet a minute. It is speeded on its way to the next stand at an 1100-foot-a-minute stage, then to 2100 feet, to 3200 feet, and to 5000 feet a minute.

"MULTICUT" "TUFCUT" "HOT WORK"
Wapakoneta
SHEAR BLADES
and ROTARY KNIVES
Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.
Rx ENGINEERED TO THE JOB
Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.
The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
Wapakoneta, Ohio

Designers and Builders of

OIL and GAS COMBUSTION SYSTEMS

to Meet Difficult

INDUSTRIAL HEATING PROBLEMS

From Soaking Pits to Forge Furnaces

STEEL PROCESSING CO.
FORT PITT BRIDGE WORKS

This output can be increased to a maximum speed of over a mile a minute. Tensiometers between each of the five stands of the operation indicate tautness of the strip metal. Speed is increased or decreased as necessary.

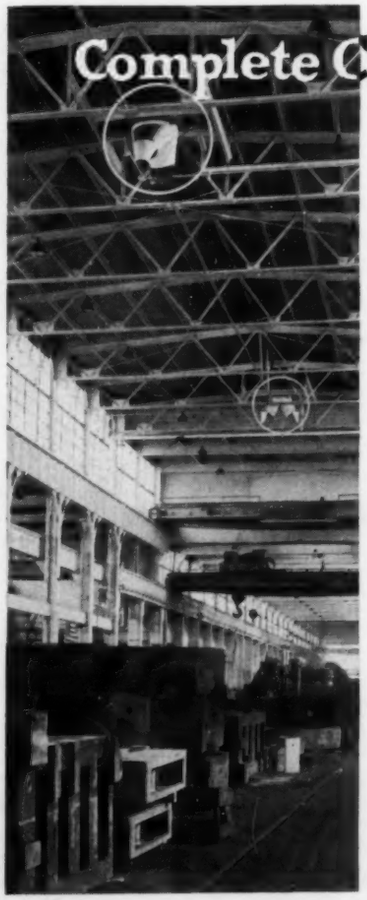
In 1928, the fastest strip mill in the world had a maximum output of only 330 feet a minute. The Weirton Steel Company set a previous record in 1939 with the installation of a strip mill, electrically equipped by Westinghouse, which rolled at the rate of 2500 feet per minute — 20 to 30 per cent faster than strip mills then operating.

LACLEDE STEEL INCREASES SCHEDULES WITH TRUCKS

▲ Illustrative of the importance attached to a study of material handling as a means to better utilization of man-power and production machines, was the action taken by the Laclede Steel Company, of St. Louis, in the wire mills at its Alton, Illinois, works several years ago. Here, in an effort to solve the production problem, not only of maintaining schedules but also of increasing them at a time when there was a diminished supply of labor, engineers made a study of the movement of material through the mills. Numerous places were found where men could be released from time-wasting, manual labor, and placed in better paying, more productive jobs; where the overall flow of material could be improved through the substitution of mechanized for manual means, and where "traffic" bottlenecks, causing production delays, could be eliminated.

Increased production was the main goal but in acting upon the report and recommendations of its engineers Laclede Steel management found that by installing storage battery-powered industrial trucks to take over movement of material to and from machines during all stages of process, into packing, storaging and finally into outward shipment, substantial savings in man-hours were realized.

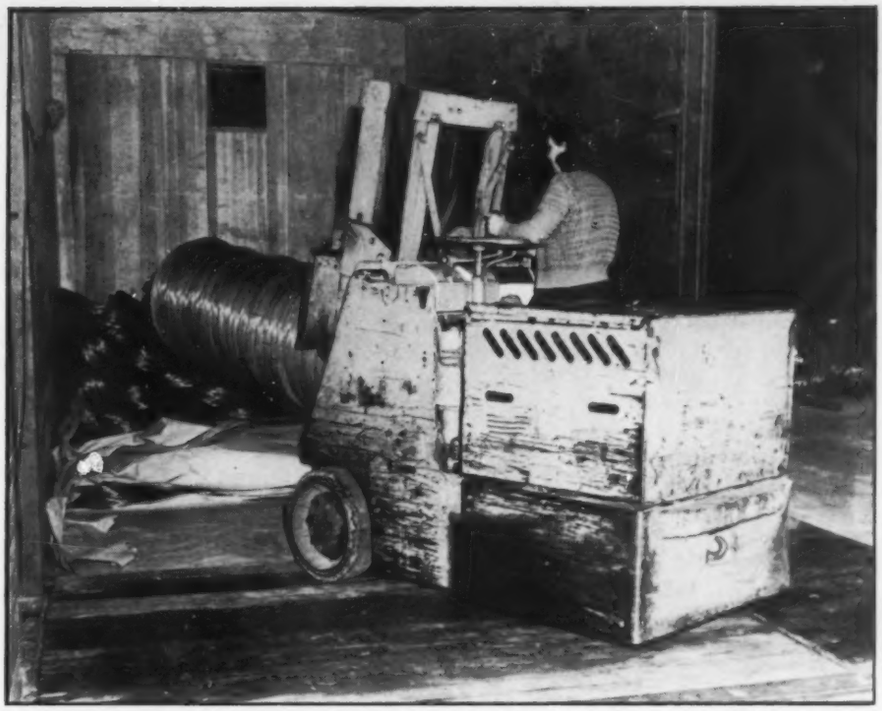
As a result of the study two battery-powered telescopic lift trucks were placed in operation. Both are of 6000 pounds capacity, and both are provided with ram and fork at-



WING Revolving Unit Heaters deliver the heated air in slowly moving streams covering successively every point in a complete circle. From their overhead locations, they project the heated air in a constantly changing direction of flow, causing it to mix uniformly, move around and under obstructions, reaching walls and remote corners and avoiding concentrated blasts of heated air. In summer with the steam turned off, it creates a delightful cooling effect. Write for bulletin.

L. J. Wing Mfg. Co., 142 W. 14th St. New York 11
Factories: Newark, N. J. and Montreal, Canada.

Wing
REVOLVING
UNIT HEATERS



Electric trucks have eliminated numerous, slow, manual handling operations. The overall movement of materials in the Laclede mills has been generally improved through the use of trucks.

tachments which are easily interchanged. Through the use of either of these attachments, as required, it has been possible to eliminate all manual labor and hand trucks in material movement. New methods of handling were devised through which the full ability of the battery-powered trucks to handle and move material quickly, safely and at a faster, more uniform speed, than was possible under slow, manual handling operations, was utilized.

For instance, in the matter of loading box-cars with coils of wire, a saving of 75 man-hours per car was realized. For each 100 man-hours required under the old hand trucking methods, one of the battery-powered trucks with the ram attachment required the expenditure of only 25 man-hours. In addition factors causing fatigue and accident have been lessened through the elevation of the ram bearing the coils of wire, to a level where the only manual movement of the coils is horizontal. All lifting of the heavy wire coils from floor level has been eliminated.

Some types of wire are shipped in barrels. These weigh 600 pounds each. Previously these were handled one at a time by a man with a two-wheeled handtruck. Now the battery-powered truck, with the fork attachment, handles six barrels at a time, the barrels being placed on pallets. Thus one man is not only able to handle six times as many barrels per load as heretofore, but less trucking time is required because of the faster movement of the truck from point to point.

STEEL FIRMS UNITE FOR CLAD STEEL MANUFACTURE

▲ The Jessop Steel Company, Washington, Pennsylvania, and the Alan Wood Steel Company, Conshohocken, Pennsylvania, have completed a working agreement whereby the technical and manufacturing facilities of both companies are to be used for large tonnage production of stainless-clad steel sheets, according to an announcement by the officials of both companies.

Jessop Steel Company is a leading producer of stainless and stainless-clad steel, as well as tool steels, alloy steels, and other specialties, while Alan Wood Steel Company has been producing open hearth quality steels for 120 years. The agreement between the two steel companies is expected to contribute greatly to meeting the current demand for stainless-clad steel sheet in the food processing and architectural industries, and the anticipated demand for this material in new

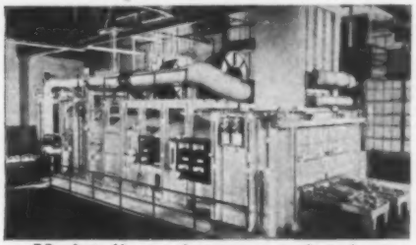
(*Please turn to page 122*)

R-S Furnace Facts

FOR THOSE CONCERNED WITH QUALITY HEATING OF METALS

Looks Efficient...and it IS!

Pic shows an R-S Continuous Wire Bar Heating Furnace at the Hawthorne Plant, Western Electric Company. Oil-fired for controlled operation at 1700°F. Ten burners at the discharge end; five over and five under the billets, and a recuperator to heat the air.



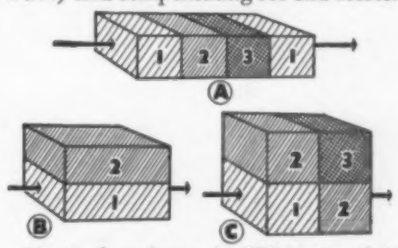
Hydraulic pushers move the charge into a heating-chamber 12' 3" wide and 38' long. Capacity is 60,000 lbs. per hour. This R-S Furnace, installed in 1930, is typical of the long life, low upkeep, and high productiveness of R-S Furnaces.

A cost-conscious heater in Lee
Had learned that M equals 3P*.
Said he in conclusion,
First cost's a delusion,
R-S is the furnace for me!

*"M" (for maintenance) is 3 times as high as "P" (for profits) according to AISE figures for the entire steel industry. R-S Furnaces have built their repute on low maintenance—in many cases literally NO maintenance—over a period of years.

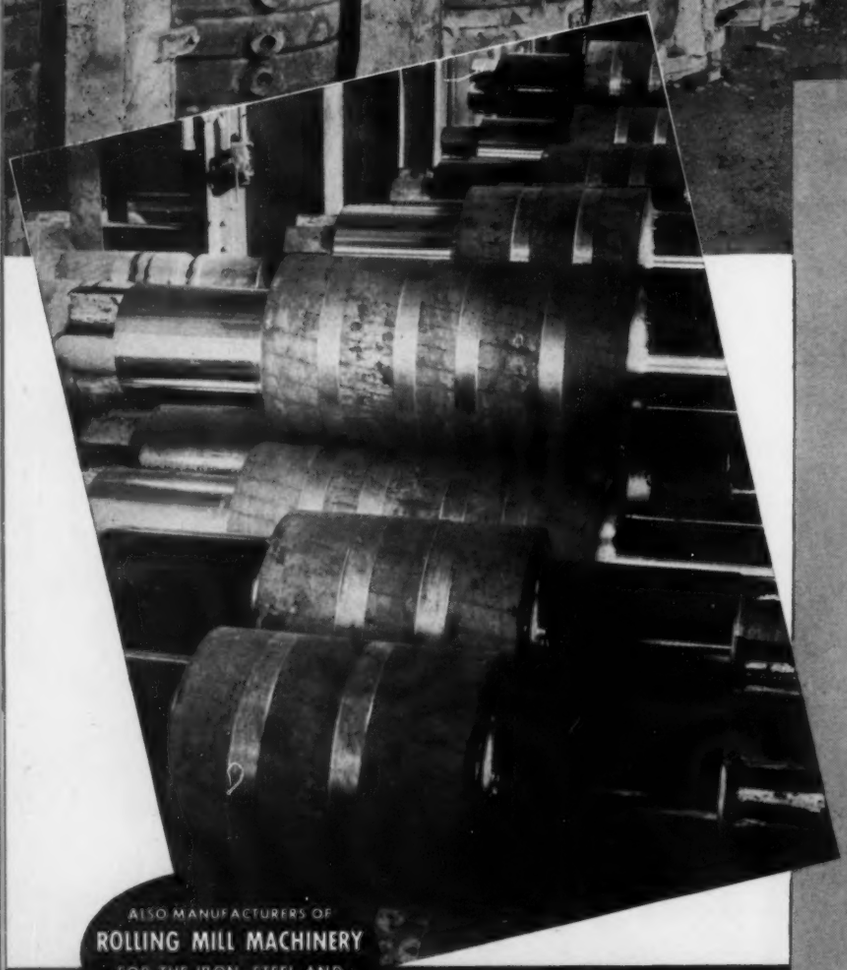
3-Way Furnace Zoning

"A" shows lengthwise zoning as used in many furnaces for establishing time-temperature cycles (continuous or step-work) and compensating for end-losses.



Vertical zoning as in "B" is rare. R-S engineers find it heats faster and gives more uniform temperatures with large charges, either batch or continuous. Combination zoning, in "C", is seldom called for, but when it is needed you can be sure that R-S engineers think vertically as well as horizontally. JMLCo P-F1

FURNACE DIVISION
R-S Products Corp.
PHILADELPHIA 44, PA.



THE BIRTH OF LEWIS ROLLS

Most small rolls are poured in practically the same manner as shown above. It's what goes *into* the molds that has given Lewis Rolls the reputation for the maintenance of peak production of rolled metals—from billets to foil.

ALSO MANUFACTURERS OF
ROLLING MILL MACHINERY
FOR THE IRON, STEEL AND NON-FERROUS INDUSTRIES

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.

Use them inside or OUTDOORS!

It's all the same to Type WMK
RAINTIGHT and WATERTIGHT*
Enclosed Safety Switch
CONDULETS

**NEMA Types III and IV*

Safety. Positive interlock prevents opening the case unless switch is "off." Dead front switch is held in "off" position while case is open.

Switches. Quick make and break mechanism. Double break, reinforced, positive pressure-type blade and jaw construction. Positive pressure fuse clips. Combination solder or solderless wire lugs.

Cast metal case. Strong and durable. Four sturdy mounting feet. Many possible threaded hub arrangements for both vertical and horizontal conduit. Cover may be padlocked to prevent unauthorized entry. Operating handle may be padlocked "on" or "off."

Permanent lubrication in the threaded operating shaft bearings resists corrosion and prevents the entrance of dust and moisture.

Horsepower ratings. 2 through 50-H.P. 30, 60, 100 or 200-ampere. 230-575-volt A.C. 250-600-volt D.C.

Listed in Condulet Catalog 2500, Section 50, Page 20.

CONDULET is a coined word registered in the U. S. Patent Office. It designates a product made only by the Crouse-Hinds Company.

A Nationwide Distribution Through Electrical Wholesalers

Our 50th Anniversary
1897 – 1947

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

Offices: Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Indianapolis Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — Portland, Ore. — San Francisco Seattle — St. Louis — Washington. *Resident Representatives:* Albany — Atlanta — Charlotte — New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

CONDULETS
FLOODLIGHTS
TRAFFIC SIGNALS
AIRPORT LIGHTING

(*Continued from page 119*)
fields, particularly for automobile accessories and home appliances.

Interest in the use of stainless-clad steel for automobile bumpers was first aroused by the shortage of electroplating equipment for chrome and nickel plating the conventional type bumper. Preliminary experiments in the fabrication of stainless-clad sheets into bumpers convinced most automobile manufacturers that stainless-clad steel offered a practical solution to the problem of pitting and flaking. It has long been recognized that the composite metal having stainless steel on the outside, backed up by low alloy, high strength steel, would provide the ideal combination of shock resistance and lasting corrosion resistance. Perfection of fabrication methods has now made stainless-clad steel an entirely practical metal for use in bumpers and other automobile accessories.

The lasting beauty and permanent rust resistance of stainless-clad steel has also attracted the interest of home appliance manufacturers.

AUTOMATIC WELDING CAN INCREASE PLANT SCHEDULES

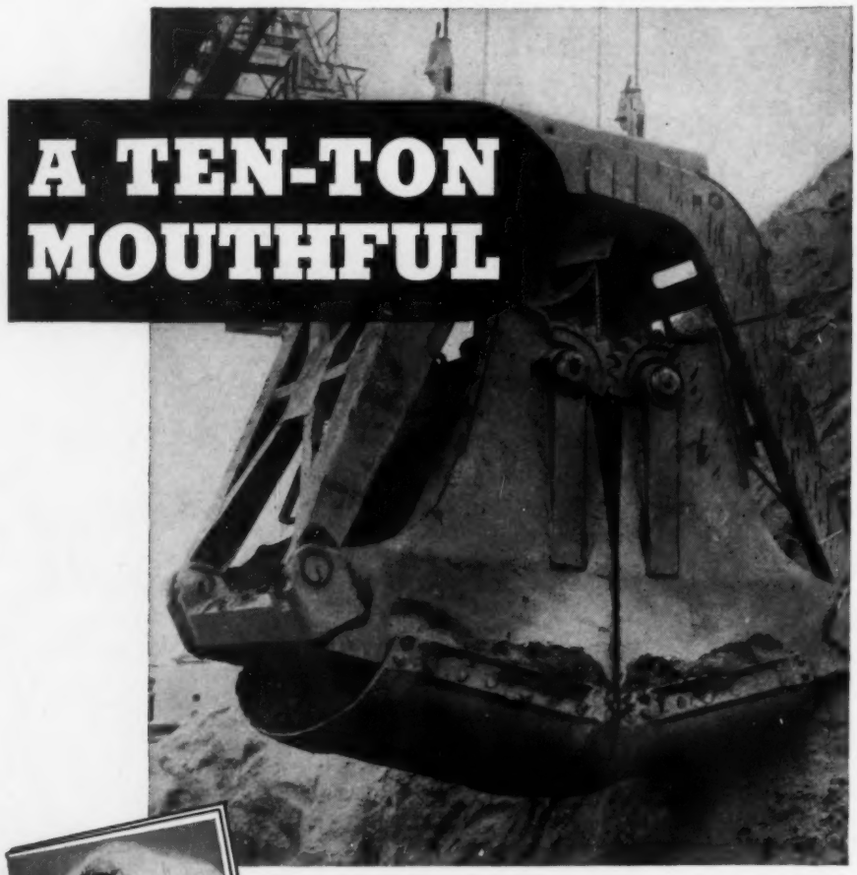
▲ Peak production of light-gage water tanks had been reached with hand welding methods at the Bell and Gossett Company of Morton Grove, Illinois. Faced with increased production schedules, the engineering department considered automatic welding with a continuous mill as a means of increasing their productive capacity.

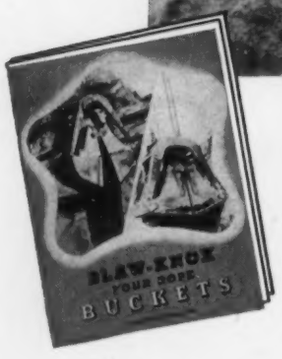
After inspecting several installations using this type fixture, the engineering personnel of this company decided that none of the current models had all the features deemed necessary for their installation. Therefore, they decided to construct a mill in their own machine shop.

The resulting mill was designed with three full-length guides which can be adjusted by a centrally located worm for tanks of different diameter. Four equispaced roller guides confine expansion in the welding zone.

The tank shells are die formed in three steps. This gives greater accuracy than rolling. The die-formed shells are then fed into the rear of the mill by a helper who starts the shell over the mandrel. The unwelded seam is split by the knife-blade mandrel support, which in turn acts as a guide to align the seam properly. The shells

The shells are fed through the mill by a series of serrated rollers which pass the shell over the mandrel and under the Unionmelt welding head.





Ore handling is no "problem" when your trolley is equipped with a 4-rope bucket of Blaw-Knox design. They're built for fast work and long wear. Alloy steel is used generously and, except for wearing parts, they are of welded construction throughout. There is a wide range of 4-rope models up to 25 tons capacity for wet ores, dry ores and river-rail coal transfer.

● *It's easy to select your bucket from Catalog No. 2059... write for it.*

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2040 Farmers Bank Bldg., Pittsburgh 22, Pa.

BLAW-KNOX CLAMSHELL BUCKETS

are fed through the mill by a series of powered serrated rollers, which pass the shell over the mandrel and under the Linde Air Products Company's Unionmelt welding head. A spring-loaded, water-cooled, copper backing shoe is incorporated in the mandrel directly under the welding zone. This keeps the molten weld puddle from falling through and yet permits 100 per cent penetration of the weld.

The mill now welds the longitudinal seam on 9-in. diameter, 14-gage water-softener tanks at 120 in. per min with 500 amperes d-c. Production has been increased to 180 units per hour so that it has not yet been necessary to operate full shifts continuously.

INTRODUCE ELECTRODES FOR MODERN WELDING

▲ A new line of tungsten electrodes for atomic-hydrogen and inert-arc welding has been announced by the electric welding division of the General Electric Company. Suitable for manual or automatic welding, the new electrodes are free from nonmetallic inclusions, segregation, slivers, cracks, seams, and pipes.

The new electrodes are available in diameters ranging from .040 to ½ in., and in lengths from 3 to 24 in. Other lengths up to 60 in. can be furnished on request. Diameters are held to 0.001 in. tolerance.

CLAIRTON STEEL PLANT SHATTERS TONNAGE RECORD

▲ In a demonstration of teamwork unparalleled since war days, the customers, the production planning department and the crews on the 22-inch mills at the Clairton, Pennsylvania, works of Carnegie-Illinois Steel Corporation worked together to shatter all previous production records set since the mill was built in 1905.

The 43-year-old mill rolls structural steel shapes for railroad cars and high tension pole line towers, and when the production planning department and the customers got together and agreed to roll larger orders of each shape it meant fewer roll changes. The crews on those mills recognized the opportunity and went to town.

According to an announcement by the Clairton works general superintendent, H. W. Seyler, records began to fall in mid-April. First "A" turn (4:00 to midnight) rolled 603 tons of structural shapes on April 13, 1947. That's 64 tons better than the old high of 539 tons for a single turn set by "B" turn a few weeks back on March 25. "A," "B" and "C" turns beat the best previous daily mark on that same day by rolling 1447 tons, 62 tons over the old record figure of 1335 tons rolled on May 13, 1942.

All three turns went on to score a new high week's production for April 13 to 19 with a total tonnage of 5789. The highest tonnage 22-inch mill No. 1 had formerly been able to produce in a week was 5670 tons from February 2 to 8, 1947.

The new daily record didn't last through the month, however. "B" turn went gunning for the "A" turn mark on April 24 and beat it by 10 tons with a total of 613 tons.

April 22 was another record breaker when the mill hung up a new production mark for billets, turning out 1252 tons, just nosing out the old record

(*Please turn to page 125*)

No other one instrument

PERFORMS ALL THESE FUNCTIONS

INDICATE AIRFLOW

INDICATE FUEL FLOW

SHOW RATIO OF AIRFLOW and FUEL FLOW

The Hays Visio-Ratio Gage is unique among indicating instruments because it performs the functions of three indicators—air-flow, fuel-flow and ratio.

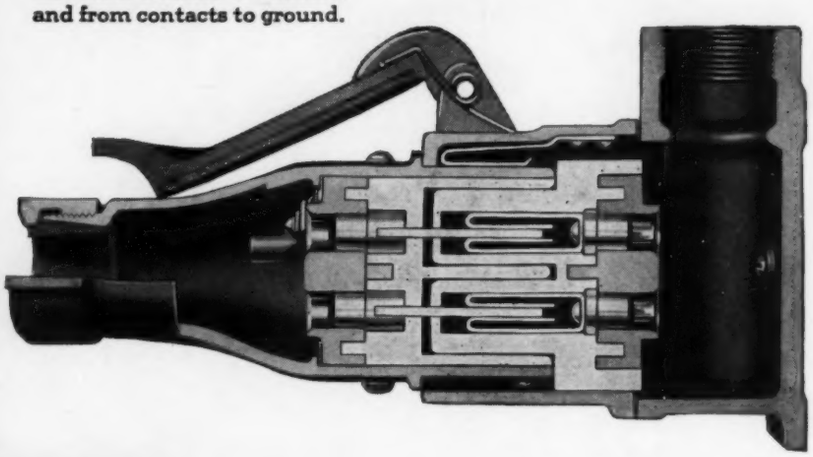
Illustrated is a Visio-Ratio Gage which measures the flow of gas to a gas fired industrial furnace and the flow of air used for the combustion of the gas. Both these scales are calibrated in rate of flow in 1000 cu. ft. per hour.

The center scale is calibrated to show the percentage of excess of deficiency of air used to burn the gas with a range of 30% deficiency to 50% excess.

The spot at which the pointers cross over the center scale indicates directly the percentage of excess of deficiency of air used for combustion, eliminating the mathematical calculations which otherwise would be required with each change in flow of gas or air. The ratio used depends on the type of flame desired—oxidizing or reducting.

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA U.S.A.

QuelArc Section; note long distances contact to contact, and from contacts to ground.



QUELARC circuit breaking plugs and receptacles

BUILT FOR MILL SERVICE

The QuelArc line of circuit breaking plugs and receptacles—ratings up to 200 amperes—is built to stand up in mill service, delivering dependable service with minimum maintenance. The exclusive QuelArc construction provides exceptional protection to the contacts, for safe use as current rupturing devices with heavy duty portable electrical equipment.

In the QuelArc design, note the complete enclosure of all contacts in insulating chambers, which form an arc-trapping space. Note also the long distances from contact to contact and from contacts to ground. Contacts are individually renewable and full ground protection is provided.

QuelArc plugs and receptacles are available in a complete line, 2, 3, 4 wire types; ratings 20, 30, 60, 100 and 200 amperes. Many other types of Pyle-National plugs and receptacles are available for portable tools, control and instrument circuits. Consult your Pylet catalog for complete listings.

PYLE-NATIONAL
RAILWAY ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY

1334-58 North Kostner Avenue • Chicago 51, Illinois

Offices: New York • Baltimore • Pittsburgh • St. Louis
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HEADLIGHTS • TURBO-GENERATORS • CONDUIT FITTINGS • FLOODLIGHTS • MULTI-VENT

(*Continued from page 123*)

total of 1247 tons turned out on January 7 of this year.

Still No. 1 was not satisfied and their almost brand new weekly record fell when the three turns collaborated to roll a total tonnage of 6350 for the week ending April 26.

Finally, the monthly tonnage totalled 21,180 tons, 685 more than the highest previous month in the mill's history, July, 1942.

Of the seven new production records marked up in April, the 22-inch crews are proudest of the new monthly total.

Crew members offered many explanations for the sudden upsurge of production. Some say it started when Jim McCormley's (No. 1 "A" turn roller) brother Jack put rival 22-inch mill number 2 out ahead on February 19 by rolling a new turn tonnage record.

Other men on No. 1 say ideal conditions had much to do with it.

The most convincing explanation comes from William Hogg, steel works superintendent.

"These records could not have been achieved without close cooperation between the crews and the production planning department, roll shop, maintenance and metallurgical departments, and our customers' willingness to go along with the schedule of rollings."

"The real significance of these new records," said Mr. Hogg, "becomes apparent when we realize they were made on a basis of 66 turns per month while the old weekly and monthly records were made when the mill was working 77 turns."

FRENCH PLANT PLACES HUGE ELECTRICAL ORDER

▲ An order for nearly six million dollars worth of electrical steel mill equipment, the largest single order for electrical steel mill equipment ever placed anywhere, has been placed with Westinghouse by the French firm of Denain Anzin.

Destined for steel mill reconstruction in Northern France, the equipment will include a 66-inch hot strip mill, powered by a main drive of 39,600 horsepower. The drives for this mill will be supplied 15,000 kilowatts of direct current power by Ignitron rectifiers.

The apparatus to be built at plants

Don't Let Handling Problems Get *You* Down! . . . . . .

Manufacturers who are striving to improve their production performance are giving material handling a lot of attention these days. They know that modern, practical handling methods are paying dividends in greater production, safety, and better employee relations. There are always many problems connected with the design and application of continuous flow handling systems, and these are often quite difficult to solve. Such problems are a headache to busy plant engineers already involved with other production details—but these same problems are the everyday work of Mathews Engineers. The Mathews people are specialists in applying *continuous flow* handling methods, and have at their command the facilities of three modern plants and the experience of nearly half a century of conveyer work in light and heavy industry. So, don't let handling problems get you down—give them to Mathews Engineers and realize the advantages that are in a conveyer service which is complete from preliminary engineering to erection in the field.

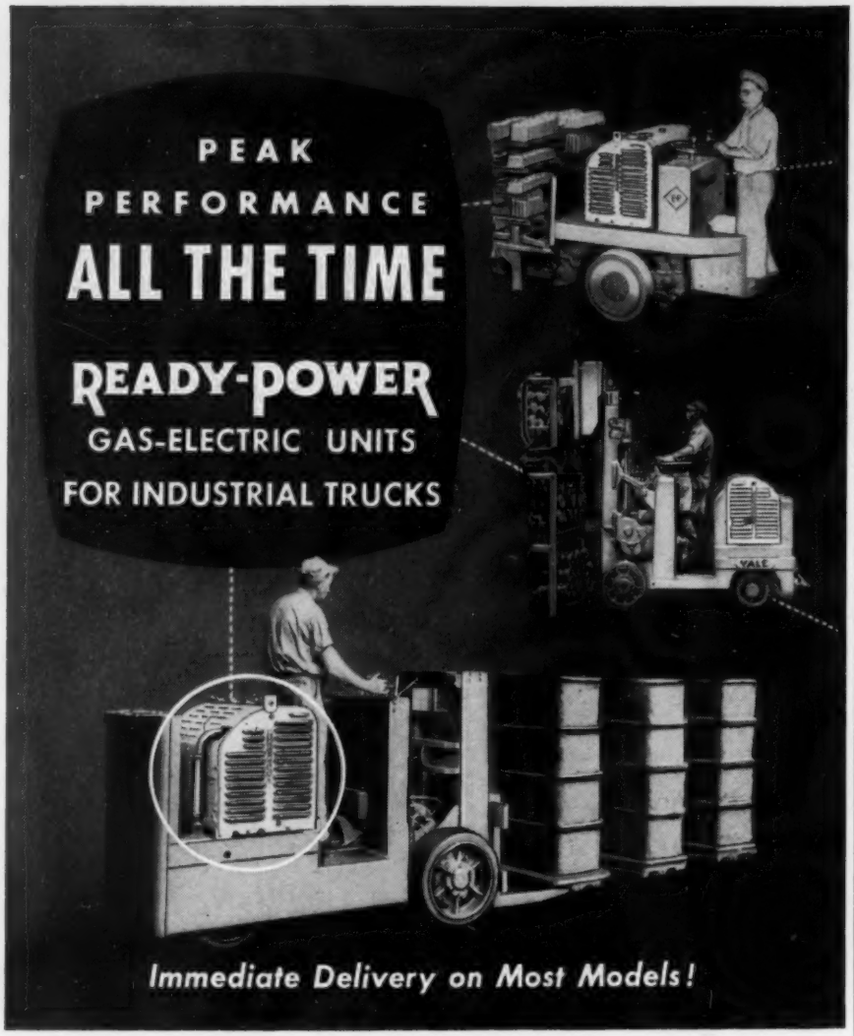
MC

MATHEWS CONVEYER COMPANY
ELLWOOD CITY, PENNSYLVANIA

MATHEWS CONVEYER COMPANY WEST COAST
SAN CARLOS, CALIFORNIA

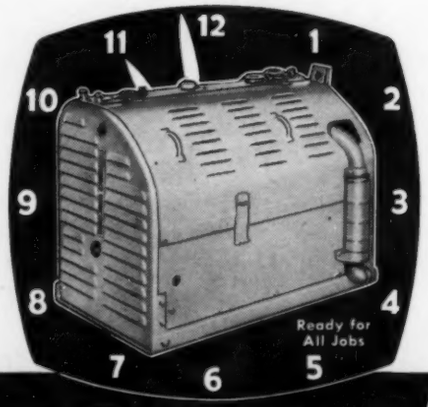
MATHEWS CONVEYER COMPANY, LTD.
PORT HOPE, ONTARIO

Engineering Offices or Sales Agencies in Principal American and Canadian Cities



READY-POWER increases the work output of Electric trucks ¼ to ½ over any other form of truck power. Electric Trucks, WITH READY-POWER, operate at the lowest cost . . . are the most efficient and longest lived of any materials handling equipment. There are no costly slow-downs or "downtimes". With READY-POWER you get higher peak performance from your electric trucks . . . more production . . . more materials moved.

Specify READY-POWER on new truck purchases. Convert present trucks to READY-POWER.



THE READY-POWER CO.

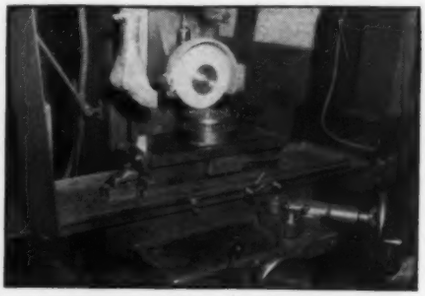
3836 Grand River Ave. - Detroit 8, Mich.

of the Westinghouse Electric Corporation will include electrically driven power units, some 700 motors, a large amount of electrical control equipment, booster and exciter equipment and various other items which will amount to a total of $5,700,000.

DEVELOP GRINDING WHEEL WITH NEW CERAMIC BLEND

▲ Several years were consumed in the development of the new "Series 20" grinding wheels by the technical laboratories of the Carborundum Company. In addition, thorough tests have been made under a diversity of production conditions in many factories.

Basically, the new grinding wheel is a completely new type of ceramic



The new wheel is shown grinding a lamination punch die. This operation, a severe interrupted cut, was performed at a table traverse of 35 fpm taking a .010 in. depth of cut.

or vitrified bonded grinding wheel, a new blend of abrasive grains. These wheels are constructed of the proper abrasive and bond to give the optimum results in grinding.

The concepts leading to the development of the wheels constitute a new and progressive step in modern abrasive engineering accomplishment. In the new wheel, factors that interfere with cutting action have been reduced, and factors contributing to higher cutting efficiency have been increased.

U. S. STEEL BUYS HOUSES FOR GENEVA EMPLOYEES

▲ The housing shortage caused U. S. Steel to buy the wartime town of Dragerton, Utah, so that employees in U. S. Steel's Geneva coal mine in Horse Canyon, Utah, might keep their homes. A total of 121 houses had been sold and moved away from the 377-acre town site before U. S. Steel

made the purchase from the War Assets administration for $1,553,000.

When the company took possession on April 1, Dragerton had 604 modern homes. In addition, there is a theatre, shopping center, postoffice, school building with auditorium, church, hospital, clinic, recreation facilities, dormitory, water facilities, sewage disposal system, and fire department.

Dragerton is a town of 3000. The homes are being rented by U. S. Steel to the occupants and to new employees. In the future, the houses will be offered for sale at fair prices.

The company immediately will organize Dragerton as a municipality under Utah state laws. It will transfer to public ownership, utilities and public improvements.

The 35-room school house will be transferred to the local school district for $1, subject to assurance that adequate educational facilities and instruction will be furnished children of the community. The community-church will be transferred to the municipality of Dragerton for $1.

Dragerton was built in 1942-1943 by the Defense Plant corporation to provide homes for coal miners in the Geneva coal mine, then owned by the government.

SYKES PREDICTS CAPACITY NOW AMPLE FOR FUTURE

▲ The present annual steel capacity of more than 91,000,000 tons would seem to be ample for our future needs for many years to come, according to Wilfred Sykes, president, Inland Steel Company, Chicago, in an address before the 55th General Meeting of American Iron and Steel Institute at the Hotel Pierre.

Mr. Sykes based his conclusion upon an analysis of the domestic per capita demand for steel for the period 1920 to 1940, which indicated that the peak per capita consumption amounted to 978 pounds in 1929. He pointed out that this peak consumption rate, plus allowance for 6,000,000 tons of steel for export, would keep only about 84 per cent of the industry's capacity in operation in 1950, and only 86 per cent in 1955. He said that these figures seem to indicate that no expansion in ingot capacity is required in the near future.

However, Mr. Sykes expressed the

(*Please turn to page 130*)

. . . Silicone-treated

DELTABESTON* CABLES

Wherever high temperatures are a real maintenance problem, economy and safety call for cables that are built to beat-the-heat. That's why more and more hot spots are getting extra wiring protection with the new silicone-treated Deltabeston cables. Asbestos-insulated and covered with a tough glass braid, these new cables are treated throughout with silicone varnish to cut *down time* and maintenance costs at operating temperatures as high as 200 C.

Silicone-treated Deltabeston cables — for 300- and 600-volt service — are built to take moisture and rough handling, too. The tough silicone impregnant keeps moisture out, fights the effects of abrasion.

UNDERWRITERS' APPROVED—These wires are approved for use in the wiring of ovens or other high-temperature equipment, such as furnaces and control apparatus, where the acceptability of the wire for the particular use has been determined by the Underwriters' Laboratories, Inc.

Let us send you specifications and working data. Write to Section Y76-646, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

*Trade-mark Reg. U. S. Pat. Off.

Beat Motor Heat with Deltabeston Magnet Wire

If you do your own motor winding – or, if you send it to an outside shop, be sure to specify Deltabeston Magnet Wire. It's made in round, square, and rectangular shapes, and is insulated with asbestos or glass for lasting protection and service.

DELTABESTON
Wires and Cables
Built to beat the heat

GENERAL ELECTRIC

Unit construction . . .

is a familiar feature of the modern telephone handset which is equally advantageous in the Torrington Self-Aligning *Spherical* Roller Bearing. Its unit design

Assures easier handling . . .

speeds assembly, cuts installation and maintenance costs. In addition, the *Spherical* Roller Bearing features high radial capacity, two-directional thrust capacity and free-rolling self-alignment that assures efficient operation under conditions of shaft deflection or similar causes of misalignment.

You can turn these and other important advantages to your benefit. Send for our Bulletin #200, which contains complete engineering data on the *Spherical* Roller Bearing.

THE TORRINGTON COMPANY

SOUTH BEND 21, INDIANA — TORRINGTON, CONN.

Offices in All Principal Cities

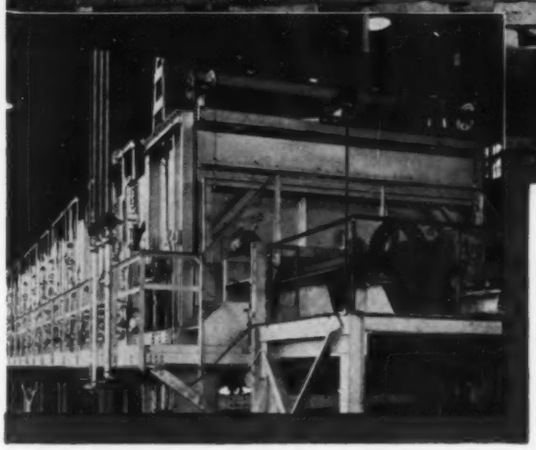
TORRINGTON BEARINGS

• NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL •

B&W REFRACTORIES

show long life in 30% CO Atmosphere

Excellent Performance leads to Repeat Orders



Photos courtesy of Swindell-Dressler Corp.

In a continuous malleableizing furnace, temperatures above 1750°F. and atmospheres up to *30% carbon monoxide* caused competitive insulating firebrick and first quality firebrick to disintegrate rapidly. They were replaced, early in 1941, with B&W Refractories—B&W 80's for the piers, B&W Insulating Firebrick for the furnace lining. These B&W Refractories are giving such satisfactory service that — when this company recently built 3 new furnaces — B&W Refractories were specified throughout!

B&W Refractories are helping to lower operating costs in all types of furnaces. Your local B&W Refractories Engineer will gladly explain how B&W Refractories can benefit you.

R-288

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

(*Continued from page 127*)
opinion that he did not believe that today's steel capacity was excessive, since he estimated that "our probable real economic capacity in this country is somewhere around 80,000,000 ingot tons per year, which balances up pretty closely with the anticipated demands within the next five or ten years." He stated that while the present rate of operation exceeds the indicated maximum demand for steel per capita, this is a condition which he feels is temporary.

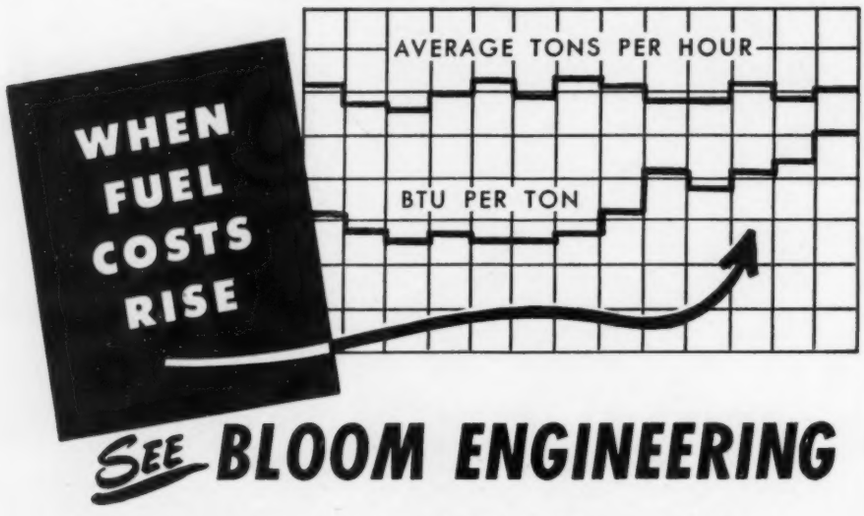
"Steel is by far the most plentiful and the cheapest of the common metals and the easiest to reduce from its ores and the simplest to fabricate," said Mr. Sykes. "The light metals and their alloys will not make inroads on the steel industry. They will create their own fields, and their production will continue to increase. So far there appears to be no substitute for steel."

In commenting on the outlook for iron ore supplies, Mr. Sykes concluded that "there is adequate iron-bearing material to meet our future needs for centuries to come." He pointed out that methods would probably be developed to work our low-grade ore deposits, and that the unexplored regions of Canada north of the Great Lakes and the new and unproven deposits in Labrador offered promising prospects.

He added that "there are strong indications that scrap will continue in short supply for some time to come." One reason for this is that the steel being made today lasts longer than steel made years ago, with the probability that it will tend to decrease the rate of scrap return over future years. Another factor lies in the increasing tonnages of light-gage rolled products, little of which ever returns as scrap. This means that steel furnaces must use more hot metal, and the eventual availability of low cost oxygen will permit use of increased percentages of hot metal.

Mr. Sykes predicted that technological improvements in iron and steel-making will be evolutionary rather than revolutionary. To achieve this progress, he said that "there must be free interchange of ideas between the men who are engaged in the industry through formal or informal channels, and the Iron and Steel Institute, through such programs as you will hear this afternoon, will be one of the prime factors in fostering progressive thought."

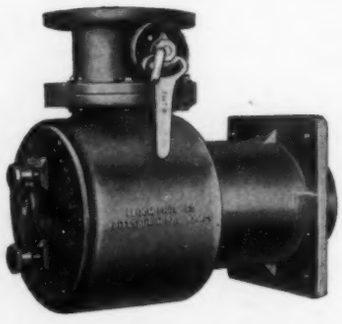
"Continued research, either in our own laboratories or cooperatively, will open new fields," he said. "Better quality and low prices will lead to new uses, and I am sure that the industry can look forward confidently to a vigorous, fruitful and profitable future."



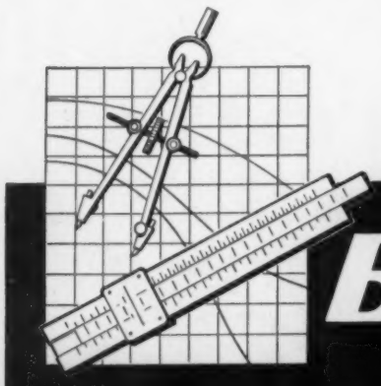
SEE BLOOM ENGINEERING

Fuel costs per ton of output are influenced by many factors —type and design of furnace, shape of roof, location of burners, kind of fuel, speed of charging and many other considerations. The correct balancing of these factors is a matter of experience and skill. Bloom Engineering has been dealing with the combustion problems in all types of heating furnaces.

If you want to reduce your fuel costs, increase production rates or improve the performance of your furnaces, see Bloom!



Bloom Long-Flame Burner. Efficient, luminous flame.



BLOOM ENGINEERING CO.

857 W. North Avenue Pittsburgh 12, Pa.

BILLET TAGGING UNIT AIDS IDENTIFICATION

▲ A new metal tagging and tag embossing outfit, primarily designed to provide a permanent and more efficient method of identifying billets during storage in yards prior to the rolling operation, is announced by M. E. Cunningham Company. The new tagging outfit has numerous warehousing and industrial applications wherever ferrous, non-ferrous or wooden products require permanent identification.

In operation, interchangeable embossing type is quickly set up in the embossing unit. After embossing with a light hammer blow, the tag is placed

The new tagging unit has numerous warehousing and industrial applications.

in a fixture which bends it to fit over the hammer face and into the hammer clamps, provided, at the same time punching a special heat treated nail through the tag. The hammer used with the tagging outfit is a regular three pound safety engineer's style tool. By swinging the hammer in the customary manner, the nail is driven into the steel billet, permanently attaching the tag for quick, easy identification.

ELECTRIC GREASE GUN NEWEST IN LUBRICATION

▲ An electric motor operated "Lubrigun" is the newest addition to the Lincoln Engineering Company's complete line of lubricating equipment. This high pressure grease gun is a streamlined, portable unit equipped with a positive displacement pump, powered by a standard make ¼ hp universal motor for 110/115 volts a-c or d-c; provides rapid, positive delivery of all types of lubricants which readily seek their own level. Unit is mounted on two large rubber tire casters and one ball-bearing swivel caster for maximum portability. Full lubricant pressure is instantly available. Capacity of lubricant container is 30 lb. A 7-ft high-pressure hose assembly with control valve, and a 12-ft electric plug-in cord are standard equipment on this model.

APPLICATION ENGINEERING REDUCES OPERATING COSTS

▲ When the Brazil Hollow Brick and Tile Company, Brazil, Indiana, recently decided to replace an obsolete 300-hp steam engine with an electric motor of like horsepower, General Electric applications engineers demonstrated that the most obvious way is not always the most economical when applying electric equipment.

The steam engine had been driving a main line shaft which was belt-connected to various other shafts and pulleys to drive such equipment as mixing pans, elevators, dryer fans, and conveyors used in the manufacture of tile conduit for telephone service. The most obvious procedure was to replace the steam engine with an electric motor on the main line shaft.

However, a tour of the plant convinced the G-E engineers that instead of a 300-hp electric motor to replace the engine, seven motors totaling 245-hp were needed to drive the various equipments individually. This would eliminate all the line shafts, which are inherently a source of trouble and maintenance, and would permit working one or more components of the system overtime without keeping the entire system in operation.

Including the primary and secondary control and the incoming switchboard, this system cost about $2500 more than the single motor, but it was installed nevertheless. As a result, production has been increased 25 per cent, and manufacturing costs have been greatly reduced. Now if the pan

BUT...

It was actually only a crude beginning in the industry which has evolved the modern stratoliner. Aviation design has constantly progressed to meet the ever-present demand for rapid and efficient transportation. In the metal working industries

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine
Duridine
Alkedine
Lithoform
Thermoil-Granodine

RUST REMOVING AND PREVENTING
Deoxidine
Peroline

PICKLING ACID INHIBITORS
Rodine

Rodine* has constantly met the demand for selective control in both sulfuric and muriatic acid pickling. RODINE minimizes acid attack on good metal but permits complete scale removal. This reduces waste of acid and metal and lengthens the life of the pickle bath.

The dangers of over-pickling, with the attendant embrittlement, are greatly lessened.

RODINE minimizes fumes, improves working conditions for the pickler and gives him effective control of the entire pickling operation.

RODINE in the pickle bath means economical scale removal, savings in acid and metal and smoother pickled surfaces.

* Trade Mark Reg. U. S. Pat. Off.

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

mixing mills get behind on mixing raw products, it is necessary to run only one 50-hp motor to catch up on production for the next day. Otherwise, the 300-hp motor along with the entire line shaft equipment would have been required for the 50-hp lead.

GAS-FIRED HEATER SOLVES PLANT HEATING PROBLEM

▲ Structural steel fabricating plants long have been difficult buildings to heat economically. They usually have high ceilings, uninsulated walls and large window areas that cause excessive heat losses.

The "pot-bellied" stoves and salamanders so often used not only are as ineffective as outdoor bonfires, but are costly in man-hours as they give the workers an excuse to warm their hands at frequent intervals.

But this heating problem has been solved in a fabricating plant just completed by Minweld Steel Company in Pittsburgh. Using a new system of space heating that operates on the principle of recirculation of warm air in the "working zone," a comfortable working temperature is maintained while at the same time roof heat losses are minimized.

The "heart" of the heating system is a single 750,000 Btu per hour gas-fired warm air heater developed by Dravo Corporation, a direct fired counterflow heater. This unit draws in cool air from all directions at the floor level, passes it over a highly efficient stabilized stainless steel combustion chamber, and then discharges the warm air at high velocity above the heads of the workers through four swivel nozzles. There is no appreciable floor draft, even a few feet away from the heater, because the air is drawn into the unit from all directions.

TIMKEN OPENS PLANT FOR CANADIAN SERVICE

▲ A new branch plant of Timken Roller Bearing Company was formally opened May 23 in St. Thomas, Ontario, Canada. In expanding its operations to Canada, the Timken company is seeking to offer better services to present and prospective customers in the Canadian markets.

Although construction on the project began May 15, 1945, a shortage of building materials held up completion of the plant until recently.

The plant is located on an industrial building site of 70 acres purchased from the City of St. Thomas. The main plant building is of concrete, brick and welded steel construction having 40-foot saw-tooth bays. Overall dimensions of the plant are 160 by 300 feet, with a single-story office section, 40 by 140 feet, in front of the plant.

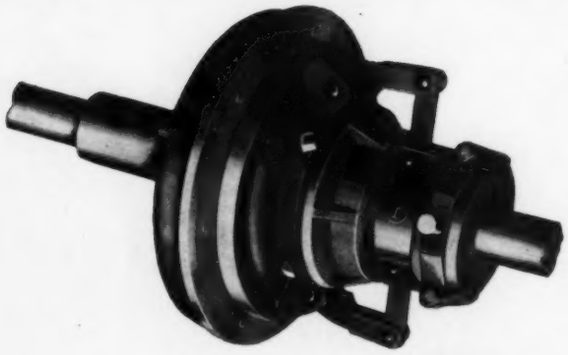
DESIGN FIBER HOSE FOR STEAM OR HYDRAULIC USE

▲ A better weapon for fighting stubborn fires with live steam was announced recently in a revolutionary type of industrial hose developed by Goodyear Tire and Rubber Company. The new type steam hose employs spun glass yarn as a basic component to gain maximum heat resistance.

Capable of carrying 200 lb of saturated steam at 388 F for more than 300 hours under continuous flexing,

(*Please turn to page 137*)

JONES-LEMLEY FRICTION CLUTCHES



JONES-LEMLEY friction clutches are built for a broad range of shaft sizes and ratings in both enclosed and open types for sleeve and coupling work. In addition they are available in a line of Jones-Lemley friction clutch pulleys. This clutch modification is also used for gears, V-belt sheaves, sprocket wheels, etc. Sizes, ratings, dimensions, prices and other data are contained in Bulletin No. 60. Your request will bring a copy.

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CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

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Here are three A.C.-D.C. electrodes that meet approximately 61% of all general-purpose, mild steel welding requirements — on production lines, or special jobs.

Airco No. 87, 90 and 230 produce weld metals of high mechanical properties. Their excellent slag coverage results in an unusually smooth deposit, with easy slag removal. Airco No. 230, for example, has a specially formulated coating that produces a spraying type of arc. This is of great assistance in the performance of vertical and overhead welding, permitting high welding speeds with excellent deposits.

All three electrodes are recommended for normal or high speed welding in the flat, vertical or overhead position and are known for their:

. . . Low Spatter Loss
. . . Light, Easily Removed Slag
. . . Unusual Smooth Weld Deposits
. . . Excellent Operating Characteristics

But learn all about these general-purpose electrodes for yourself. Ask for Airco Electrode Catalog No. 120A. Just fill in and mail the coupon for your copy. Address: Air Reduction, General Offices, 60 East 42nd Street, New York 17, N. Y. In Texas: Magnolia Airco Gas Products Co., General Offices, Houston 1, Texas. Represented Internationally by Airco Export Corp.

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Please send me the Airco Electrode Catalog No. 120A.

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What does it take to build a good coke oven plant?

IT TAKES A GOOD BASIC DESIGN.

We believe the Koppers-Becker Coke Ovens have the best of all designs . . . sturdy, free from complications, simple to control, with the largest practical coking capacity. This design can be used over a wide variety of conditions, making metallurgical or domestic coke with heating by any kind of fuel gas normally available, and in large or small sized ovens. The ovens are accessible throughout; this means low maintenance and long life.

IT TAKES CONSTANT ENGINEERING REFINEMENT.

The number of coke oven plants which Koppers builds gives this company an unparalleled opportunity to develop new ideas to meet the new needs.

For example, the waste gas recirculation system was developed by Koppers to meet the need for greater coal carbonization capacity per oven. To produce more coke from ovens, it became necessary to make them greater in height. To get uniform heat in walls of very high ovens, when heating with coke oven gas, it was necessary to delay the rate of combustion. This has been accomplished with the waste gas recirculation system.

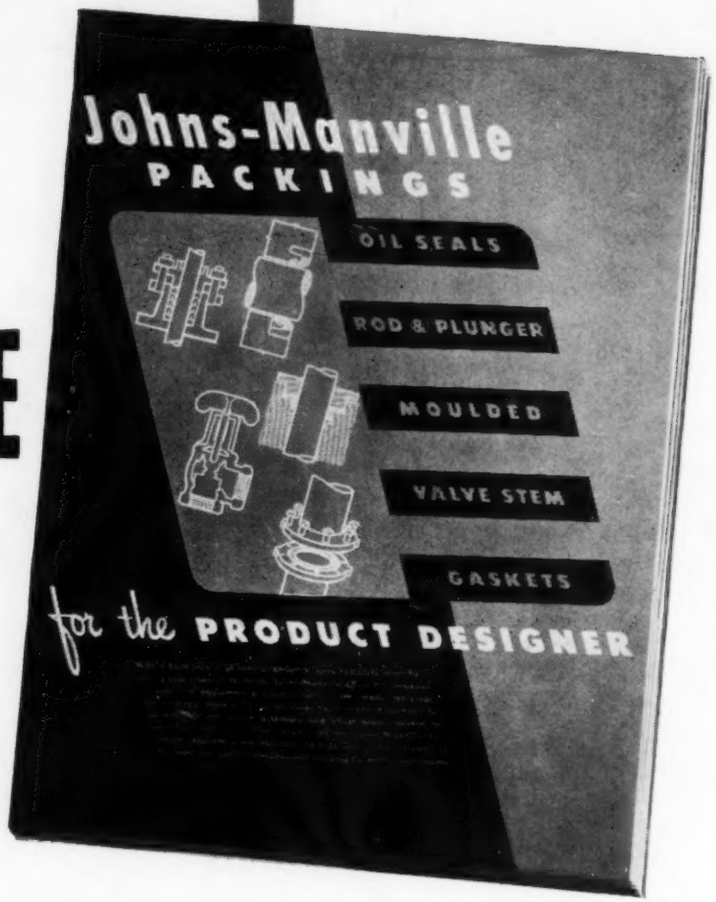
IT TAKES A FINE ENGINEERING STAFF.

The Koppers engineering staff has proved its ability to design and erect the most advanced and efficient coal carbonization, material handling and gas treatment equipment.

K KOPPERS

KOPPERS COMPANY, INC. KOPPERS BUILDING, PITTSBURGH, PA.

Send for this *New* PACKING GUIDE



If you're looking for a packing that will help you simplify design, speed assembly or reduce production costs, here is a booklet you should have!

Prepared by J-M's engineering department especially for the product designer, it presents up-to-the-minute factual information about the Johns-Manville Packings listed below . . . packings that have become "standard equipment" with manufacturers of many types of products. It includes specifications, sizes and other data in handy tabular form to save time, simplify selection.

"Johns-Manville Packings for the Product Designer" is yours for the asking. To obtain your copy, simply mail the coupon.

COVERS THE FOLLOWING J-M PACKINGS:

J-M Sea Rings—the rod and plunger packing that automatically seals on the work stroke, releases on the return.

J-M Clipper Seals—an efficient lubricant-retaining, dirt-excluding oil seal of unique design.

J-M Moulded Packings—custom made exactly to your specifications for hydraulic and pneumatic equipment.

J-M Die Formed Rings—precision manufactured to insure perfect mechanical fit, speed product assembly.

J-M Kearsarge—the rod packing with the accordion folded center block that acts as a reservoir for the lubricant.

J-M Flexible Metallic Packings—both all metal and semi-metallic packings for high speeds, pressures and temperatures.

J-M Interlocked—the square braided packing with no jackets to wear through, no plaits to loosen.

J-M Gaskets—cut exactly to specifications from a wide variety of gasketing materials.

Also J-M Gasketing Tapes, Groove Packings, and Wick and Rope Packings.

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PACKINGS & GASKETS

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Send me a copy of your free booklet: "Johns-Manville Packings for the Product Designer."

NAME_____

COMPANY_____

STREET AND NO._____

CITY_____ ZONE____ STATE_____

(*Continued from page 132*)

it is said the new glass fiber hose will greatly increase the steam volume used in smothering oil fires such as recently devastated Texas City.

This amount of pressure would char and burst ordinary hose, which has a fabric carcass and is seldom recommended for steam pressure exceeding 100 pounds,.

In the development stage for several years, chief difficulty in perfecting the hose was getting a glass cord capable of withstanding maximum flexing required in steam service. A bonding technique developed by Goodyear during the war is used to achieve high adhesive strength between the hose's glass carcass, rubber tube and cover.

The new hose is designed also for heavy-duty steam or hydraulic service in steel mills and other heavy industries. The glass cord is made by the Owens-Corning Fiberglas Corporation.

DIAPHRAGM AIR MOTOR IS IN FULL PRODUCTION

▲ The North American Manufacturing Company has designed a new product known as the "Series 600" diaphragm air motor. Pneumatic control system users in the metal industries will appreciate the advantages offered by this new motor. It is designed primarily for use with North American adjustable port valves which have the adaptability feature necessary for straight-line flow control, but it can be used wherever the need for pneumatic control might arise.

Accepted pneumatic controller air pressures of 0 to 15 psi afford an impulse pressure range of 3 to 13 psi to the diaphragm motor which results in full travel of the motor arm (26 degrees) and develops 25 lb/in. torque for 1 lb change in impulse pressure. These ratings are for the No. 600-65 size motor.

Provisions have been made on the diaphragm motor for a valve positioner to obtain the maximum in valve response accuracy.

WESTINGHOUSE BUSINESS AT PEACETIME RECORD

▲ The Westinghouse Electric Corportation turned out a new peacetime record of $58,485,244 worth of products during April, Gwilym A. Price, president of the company has reported. These products ranged from irons and vacuum cleaners to huge generators and steel mill equipment.

In a report to the company's board of directors, Mr. Price disclosed that this dollar volume of production, as shown by sales billed, was $8,000,000 larger than the previous high peacetime month of March, 1947. This volume compares favorably with many wartime months.

The Westinghouse president pointed out, however, that in the past every inflationary period had been followed by a recession, and that there had been numerous forecasts of such a recession recently. Despite this, he said, the postwar plateau of unusually good business still continues for Westinghouse, and the outlook is that it will continue for some months to come.

Production gains were spread generally throughout Westinghouse divisions, with the greatest increase made

(*Please turn to page 162*)

Advanced **PEERLESS JET PUMPS**

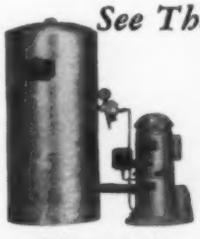
Economically Produce the Water You Require for Light Industrial Needs

Capacities: 120 to 7500 Gals. per Hour. FROM WELL DEPTHS TO 120 FEET.

The Peerless engineering achievement of designing and building more efficient pumps with fewer moving parts has again been most successfully applied in the advanced Peerless Jet Pumping System. The trouble-free Peerless Jet Pump principle ingeniously applies the natural force of gravity, plus a minimum of mechanical power, to lift water upward by pressure from the Jet and force it to a pressure tank by means of an impeller. There is no simpler pump principle now being utilized where water lift requirements are comparable.

Peerless Jet Pumps are easy to understand, install, operate and maintain. Once the constant-pressure Jet Pump is in operation, adjustment or repair is rarely needed. Extremely compact in design. Double or single pipe systems available in sizes from ¼ to 3 H.P. Quietly supplies the water you require whether installed over the well or offset at a distance from the water source.

Ideally applied to wells 2" inside diameter and larger for water supply requirements of light industry including ice and refrigeration plants, creameries, dairies, milk plants, institutions, hotels, laundries. municipalities, motels, schools, etc.



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See The **PEERLESS Water King** ***Unique in design and operation. For shallow well installation only.***

CAPACITIES: 275 to 860 Gals. per Hour. For trouble-free simplicity of operation, this unique pump utilizes the same "magic" pumping element of the Peerless Hi-Lift Pump. Hard chrome pumping element wholly positioned and protected within pump base is highly resistant to abrasive and corrosive action. Assures a clean constant water supply. Requires a minimum of space and attention. 100% automatic. Easily installed over well or off-set.

Write for Bulletins describing these two most efficient pumps.

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Factories: Canton 6, Ohio • Quincy, Ill. • Los Angeles 31, Calif.

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Atlanta: Rutland Bldg., Decatur, Ga.; Dallas 1, Texas

Personnel News . . . .

W. R. Elliot, formerly assistant general superintendent, has been promoted to general superintendent, Otis works of Jones and Laughlin Steel Corporation at Cleveland, Ohio. Mr. Elliot was born and educated in

W. R. ELLIOT

Canada. Prior to coming to Otis Steel Company in 1925 as a foreman in the 30 in. cold strip department, he was employed first by the Baldwin Steel Company of Toronto and later by Midland Steel Products Company in Detroit and in Cleveland. From 1926 to 1934 he was manager of orders for Otis Steel Company. From 1934 to 1942, he was assistant to the vice president of Otis and was in charge of operations. Since the acquisition of the business and assets of the Otis Steel Company by Jones and Laughlin on June 30, 1942, he has been assistant general superintendent of the Otis works.

E. N. McKelvey, formerly superintendent of the Lakeside division of the Otis works, has been appointed assistant to the general superintendent of the Otis works, succeeding **F. W. Mumper** who has been transferred to the general offices of Jones and Laughlin at Pittsburgh, as director of personnel and industrial relations. Mr. McKelvey prior to coming to Otis works as superintendent of the Lakeside plant was general manager of the Steubenville plant of the Wheeling Steel Corporation.

E. F. Blank, formerly director of personnel relations and **W. H. Harvey,** formerly assistant director of per-

E. F. BLANK

sonnel relations, have been appointed assistants to the vice president in charge of personnel and industrial

NAME O. P. ASHURST SECRETARY AISE DETROIT DISTRICT SECTION

O. P. Ashurst has been appointed secretary of the AISE Detroit district section. Mr. Ashurst is employed by Giffels and Vallet, Inc., Detroit, Michigan as chief project engineer, steel mill division. His headquarters are in Room 1000, Marquette Building, Detroit 26, Michigan.

Mr. Ashurst was born and educated in England, and, in 1924, went as a student with Canadian Bridge Company, Walkerville, Ontario, Canada (at that time a U. S. Steel subsidiary) for 2½ years. Three years were spent acquiring general construction experience, before joining his present company in 1929. Since 1934, he has specialized in steel mill work exclusively.

Mr. Ashurst will succeed Elmer F. Weiss, district manager of Cutler-Hammer, Inc., who recently resigned and who has been district secretary since the formation of the Detroit District Section in 1938.

relations for Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

F. W. Mumper has been appointed director of personnel and industrial relations. He had been assistant to the general superintendent of the Otis works of Jones and Laughlin and had formerly been assistant to the vice president in charge of operations of Wheeling Steel Corporation.

E. A. Irwin, general sales manager, was elected vice president in charge of sales, and **Ray H. Sullivan,** Brooklyn division manager, was named vice president in charge of manufacturing for E. W. Bliss Company.

Prior to his appointment as general sales manager in October 1946, Mr. Irwin had been the managing director of E. W. Bliss Company of Canada, Ltd. for five years. He has been associated with the company for over twenty-seven years.

Mr. Sullivan, who joined the Bliss company last October as works manager of the Brooklyn plant, has

RAY H. SULLIVAN

an extensive background in directing the manufacturing operations of several leading corporations. For a number of years he was with General Motors Corporation, serving consecutively as assistant general factory manager of the Ternstedt unit and as assistant to the director of operations of the Fisher Body division. He left General Motors to become works manager of the Ingersoll Steel division of Borg-Warner Corporation, where he supervised the operations of their Chicago plant. Before joining the Bliss Company, Mr. Sullivan was assistant general manager of the U. S. Cartridge Company in charge of operations at the St. Louis ordnance plant.

Herman F. Dobscha, superintendent of blast furnaces, Edgar Thomson Works, Carnegie-Illinois Steel Corporation, Pittsburgh, was given the American Iron and Steel Institute Medal at the 55th General Meeting of the Institute.

The Institute Medal, established in 1927 to perpetuate the memory of the late Elbert H. Gary, founder and first president of the Institute, is awarded for a paper read before the Institute, having special merit and importance in connection with the activities and interests of the iron and steel industry.

Mr. Dobscha's medal winning paper, presented at the Institute meeting in 1946, was titled, "Effect of

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saves thousands of dollars by eliminating serious breakdowns in pumps and piping systems.

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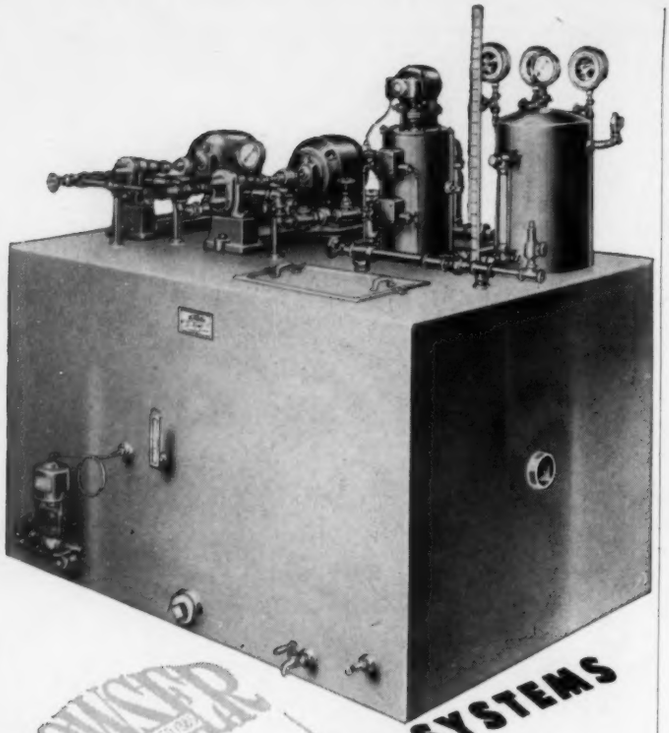

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CIRCULATING, FILTERED LUBRICATING OIL •

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More than forty years of knowledge and experience in designing and building industrial lubricating equipment are reflected in the dependable performance of every Bowser system.
Sizes range from self-contained units for individual machines to systems that serve entire plants.
Many steel mills and other industrial plants are using Bowser Lubricating Systems to provide a continuous supply of clean oil for important production equipment . . . to minimize maintenance costs and downtime.

A Bowser Lubrication Engineer will be glad to check the lubrication needs of your plant at your convenience. Write today to

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LIQUID CONTROL SPECIALISTS
SINCE 1885

Sized and Nodulized Mesabi Iron Ores on Blast Furnace Performance."

H. E. Boedecker has been appointed general superintendent of electrical and mechanical maintenance, Companhia Siderurgica Nacional (Brazilian National Steel Company), Volta Redonda, Estado de Rio, Brazil. Mr. Boedecker formerly has been connected with the following companies: LaBelle Iron works, now part of Wheeling Steel Corporation; Farrell works of Carnegie-Illinois Steel Corporation; American Rolling Mill Company; Tennessee Coal, Iron, and Railroad Company, Birmingham, Alabama; Wisconsin Steel Company; Jones and Laughlin Steel Corporation; and Crucible Steel Company of America, Pittsburgh, in capacities of electrical superintendent, mechanical superintendent, and superintendent of electrical and mechanical maintenance; superintendent of electrical and mechanical departments, Atlas Steels Limited, Welland, Ontario, Canada; assistant general superintendent, Pittsburgh Metallurgical Company, Charleston, South Carolina; superintendent of shops, Indiana Harbor Works of the Youngstown Sheet and Tube Company, East Chicago, Indiana.

H. E. BOEDECKER

L. C. Grimshaw has been appointed metallurgical engineer of the Clad Products division of Jessop Steel Company, Washington, Pennsylvania. He will assist in the development, manufacture, and application of Jessop's composite metals, including Jessop stainless-clad steel.

Prior to joining the Jessop Steel Company in 1947, Mr. Grimshaw was chief metallurgist for five years and superintendent of the clad steel division for two years at Latrobe Electric Steel Company. Following his graduation from Rensselaer Polytechnic Institute in 1928, he was employed by Ludlum Steel Company (now part of Allegheny-Ludlum Steel Corporation). He has taken post graduate work in metallurgy at Columbia University.

Frank D. Hazen, who has been general sales manager of the industrial department of American Arch Company, Inc., New York locomotive equipment firm, has been appointed vice president and general manager

of the department, with headquarters at 1430 Park Building, Pittsburgh, Pennsylvania.

Mr. Hazen has been associated with American Arch Company for 22 years. For eight years prior to joining the company he was engaged in construction work for the Inland Steel Company and the Illinois Steel Company. During World War I he served as an ensign in the U. S. Navy.

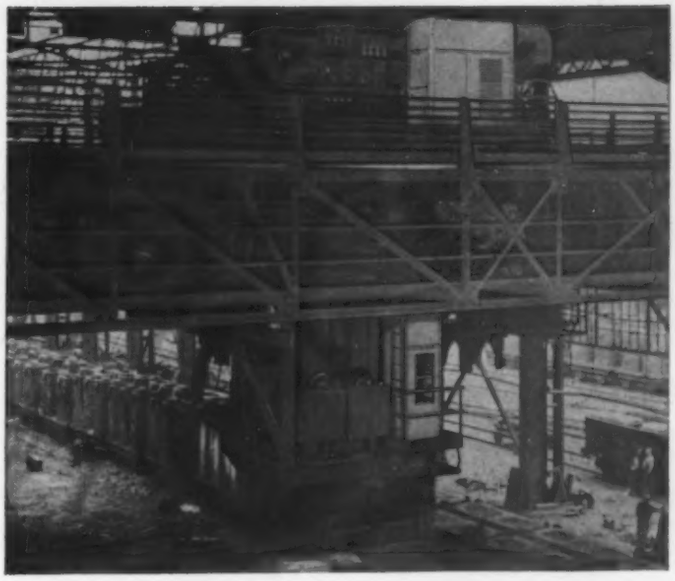
E. R. Monesmith has been appointed general sales manager of Crouse-Hinds Company, Syracuse, New York, succeeding **A. F. Hills,** who continues as vice president and director of sales. Mr. Monesmith is a native of Colorado, where he took a course in electrical engineering at the University of Colorado. At the outbreak of World War I, he enlisted in the Army and when mustered out completed his electrical education. In July 1926, he joined the Crouse-Hinds Company with his headquarters in Washington, D. C. For several years thereafter he acted in the capacity of sales engi-

E. R. MONESMITH

neer handling first traffic signals, and later floodlights and airport lighting equipment were added. His territory included from Trenton, New Jersey to South Carolina. From 1931 to 1934, Mr. Monesmith's activities were extended to include the sale of all Crouse-Hinds products. He specialized in work with the federal government in Washington, where he continued to maintain his headquarters. In January 1935 he was transferred to headquarters at Syracuse, New York, with the title of field engineer. His scope of operations included the entire United States, thus allowing him to act as liaison between headquarters at Syracuse and the field representatives and customers. With his long and extended experience, Mr. Monesmith is exceptionally well-qualified to assume the new duties and responsibilities placed upon him. He will make his headquarters in Syracuse, but will spend a large portion of his time in the field.

Richard T. Nalle has been elected president of Midvale Company, Nicetown, Philadelphia, Pennsylvania, succeeding **Francis Bradley** who has been elected chairman of the board of directors.

Arthur F. Bixby, heavy chemicals salesman in the Philadelphia, Pennsylvania, office of the Pennsylvania Salt Manufacturing Company for the past nine years,



Soaking Pit Crane in plant of a prominent steel company, equipped with Lintern Aire-Rectifier 145 AC-24.

The Only Crane Cab Conditioner Thoroughly Tested on Soaking Pit Applications

In the illustration above the Lintern Aire-Rectifier was tested on the particular crane shown. It is the center crane of three.

After last summer's test the plant installed Lintern Aire-Rectifiers on the other two cranes.

Soaking pit crane cabs are the most difficult to air condition. We have done it with units which over the months and years have demonstrated their *low* maintenance.

Lintern *balanced refrigeration* design prevents overloads in temperature as high as 170° F. This is the only crane cab conditioner which has had thorough testing on soaking pit applications. It is tried and proved. Only periodic inspection is required.

Ask for Bulletin AC 11546

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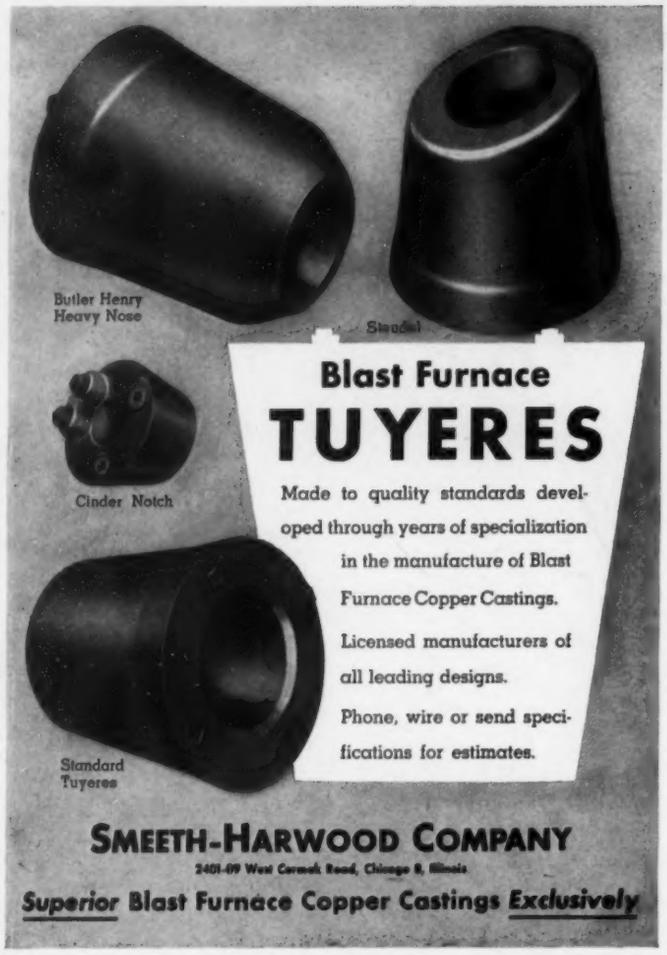
Glowlite Signals, Lanterns, Sanders, Shock Absorbers for Lamps, Ventilating Heaters, Aire-Rectifiers for Overhead Cranes.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Superior Blast Furnace Copper Castings Exclusively

Advantages of Haven
DOUBLE-COMPARTMENT COOLING PLATES
Made by
FALCON'S
ANCHORLESS METHOD
1 Direct cold water feed to nose where it is needed.
2 Cold water cooling value maintained in back compartment at all times should it become necessary to shut water off at nose.
3 Independent inlet and outlet for both compartments.
4 Transverse, staggered baffles provide circulation for maximum employment of cooling water and elimination of sediment deposits.
5 Falcon quality casting.
Patent No. 1,827,231
TELEPHONE COLLECT
FALCON BRONZE CO.
YOUNGSTOWN 3 OHIO

has been transferred to the Pittsburgh, Pennsylvania, office.

Mr. Bixby takes the place of **C. W. Dermitt,** who recently was transferred to Cincinnati to become district sales manager.

John A. Worthington has been appointed general sales manager of the piston ring division of Koppers Company, Inc. Mr. Worthington is a native of Annapolis, Maryland, and joined the Bartlett Hayward Company, now a division of Koppers, in 1916 after attending St. Johns College and Johns Hopkins University night school.

At Bartlett Hayward he started as an inspector and in three years became a foreman. In 1920 he was transferred to the American Hammered Piston Ring division as assistant shop superintendent. Two years later he became an engineer in that division and since 1925 has been manager of industrial sales and engineering.

T. F. Olt was appointed director of research for American Rolling Mill Company, Middletown, Ohio. Mr. Olt joined Armco in 1928 as a metallurgical assistant at the East works plant. Two years later he became metallurgist. In 1932, he was made senior metallurgist

T. F. OLT

at East works. He was appointed senior research engineer in 1934. Later he became supervising metallurgist. In 1940, he advanced to associate director of research. He became assistant director in 1945. Mr. Olt succeeds **Dr. Anson Hayes,** who is retiring as director of research. Dr. Hayes has been appointed director emeritus and will continue to be very active with respect to research policies.

R. Bruce Hunter has been appointed manager of the Gary, Indiana, plant of American Bridge Company. **W. A. Thiel,** who is succeeded by Mr. Hunter, has been placed in charge of construction and maintenance of the company's western division plants at Gary and Minneapolis, Minnesota.

Mr. Hunter was born in Youngstown, Ohio, and began with American Bridge Company in 1912 as a templet maker at the Gary plant. He has been manager of the company's Trenton, New Jersey, plant since 1943. Prior to his transfer to Trenton, Mr. Hunter had 25 years' service at the Gary plant.

George M. Thursby was elected vice president in charge of industrial relations and **William Foster** was elected secretary of H. C. Frick Coke Company. Mr.

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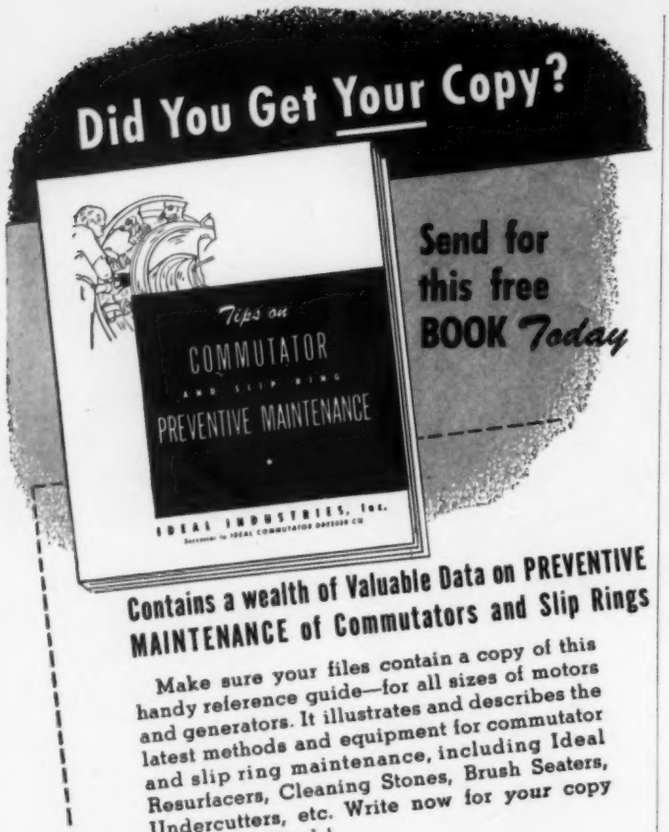
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Foster also has been elected secretary of United States Coal and Coke Company. He will continue his former position as general attorney for both subsidiaries.

Mr. Thursby has been director of industrial relations for Frick and associated companies since February 1944. He started with U. S. Steel in 1921, was appointed casualty manager for Frick in 1935, and became assistant secretary in 1939. He is a native of Pittsburgh and a graduate of Duquesne University.

Also a native of Pittsburgh, Mr. Foster was graduated from Princeton University in 1934 and from the University of Pittsburgh law school in 1937. In general practice of law here until 1941, he was then appointed chief of the legal section on ammunition for the Pittsburgh Ordnance District. Two years later he joined the law department of U. S. Steel Corporation of Delaware. He was appointed general attorney of Frick in January 1946.

Harold V. Engh, executive vice president of Anaconda Wire and Cable Company, New York, has been elected president and general manager of Pyle-National Company. Mr. Engh is a native of Chicago and a product of its public schools and of Lane Tech. He started

HAROLD V. ENGH

his business career with Chicago Insulated Wire and Manufacturing Company and rose steadily, serving in various departments. He enlisted in the U. S. Army air service and served both here and abroad as an officer pilot during the first World War. Before he reached his twenty-seventh birthday he was elected vice president of Illinois Wire and Cable Company. In 1928 he became president of Inland Cable Company. When Inland consolidated with Anaconda Wire and Cable Company in 1929, Mr. Engh joined Anaconda as vice president.

Jacob S. Disston, Jr., has been elected president of Henry Disston and Sons, Inc., manufacturers of high quality steels and cutting tools, the board of directors have announced. Mr. Disston, who was vice president for 14 years, succeeds **S. Horace Disston,** who has advanced to chairman of the board.

Henry W. Kayser has recently assumed new responsibilities at Falk Corporation with his appointment as supervisor of development engineering. Mr. Kayser has been associated with Falk Corporation as designer, application engineer, and development engineer since his graduation from Marquette University College of Engineering in 1931.

Clark E. Korns has been appointed supervisor of industrial relations for Youngstown Sheet and Tube Company's Chicago district plants. Mr. Korns came to the company in 1940 as assistant to the general superintendent of the strip and tin mills at the Indiana Harbor works. Before that he was with Cambria Steel Company and Wheeling Steel Corporation, serving as superintendent of inspection and tests and later as general superintendent of Wheeling's Portsmouth, Ohio, works.

In his new position Mr. Korns succeeds **Herman J. Spoerer,** recently transferred to general offices in Youngstown as director of industrial relations for all the company's plants.

Herman J. Spoerer, supervisor of industrial relations in the Chicago district for Youngstown Sheet and Tube Company, has been appointed director of industrial relations for the entire company. Mr. Spoerer is being transferred from the Indiana Harbor, Indiana, plant to the company's general offices in the Stambaugh Building at Youngstown, Ohio.

Mr. Spoerer joined the traffic department at the company's South Chicago plant in 1918. A year later he

HERMAN J. SPOERER

was made safety inspector and a short time later the employment department was placed under his supervision.

In 1923 he was transferred to the Evanston, Indiana works to become personnel manager. He was transferred to Indiana Harbor as chief safety inspector in 1936 and a short time later was made supervisor of industrial relations in the Chicago district.

R. H. Kutscher has recently been appointed manager for the Pittsburgh sales territory of Electric Machinery Manufacturing Company. He succeeds **H. L. Renking,** who became district manager of the southwestern territory, with headquarters at Dallas, Texas.

Mr. Kutscher is an electrical engineering graduate of the University of Minnesota. Since graduation in 1936, he has been at the general office of Electric Machinery Manufacturing Company at Minneapolis, Minnesota, specializing in application engineering, and for the last eight years has also been manager of the service department.

George W. Sweeny was elected vice president of United States Coal and Coke Company. Mr. Sweeny will continue his present position as vice president,

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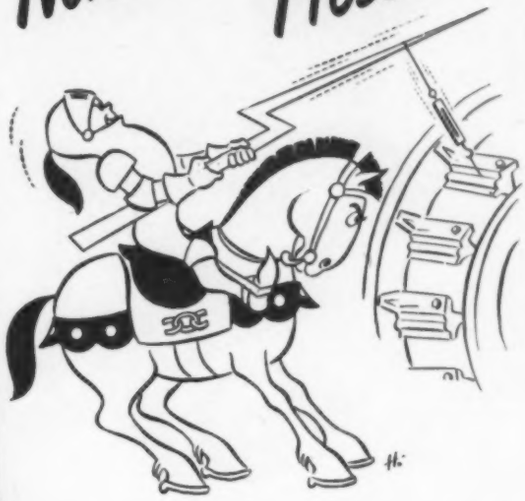
on better brush performance —

No. 2-Spring Pressure



The desirability of correct and uniform brush pressure cannot be disputed. When it isn't possible to adjust the tension to the exact value prescribed, adjust to a point which is slightly above rather than below the recommended pressure. Occasionally the operator may find the pressure for best results to be somewhat greater or less than the manufacturer's recommendation. Above all, uniform pressures are most important. Morganite quality control guarantees uniformity of material — a combination of the two assures satisfaction.

When checking brush pressures with your spring balance, remember that the brush should move freely in its holder and that allowance should be made for the weight of heavy metallic brushes acting either with or against the pull of the spring.

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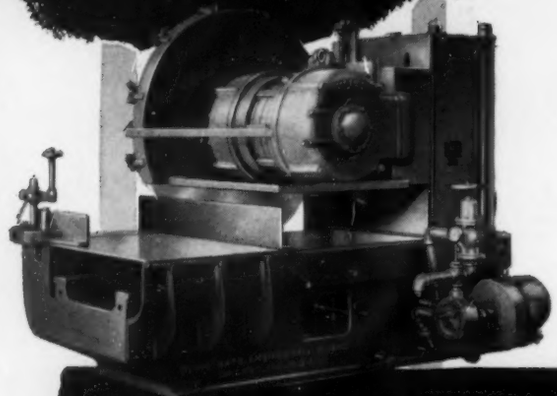
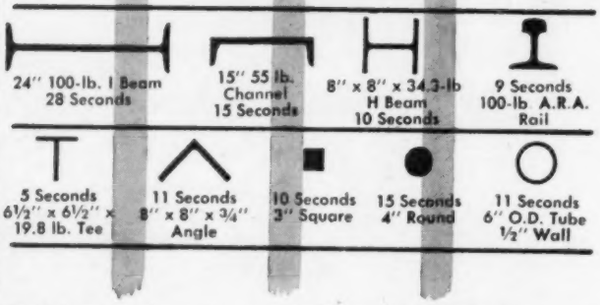
Modern Sawing



with KLING HIGH SPEED FRICTION SAWS



Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

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H. C. Frick Coke Company, and as auditor of United States Coal and Coke and associated Frick companies.

A native of Lehighton, Pennsylvania, Mr. Sweeny attended Albright College and was graduated from Pennsylvania State College in 1907. He began with Frick as paymaster in 1908 and held various positions until his election as vice president in 1940. He was secretary and treasurer of the company for 13 years preceding that.

Anthony M. Kohler and **Alan E. Phin** were elected as vice presidents of the Babcock and Wilcox Company. Mr. Kohler joined the company in 1913 as production engineer and worked at the Bayonne, New Jersey plant. When, in 1920, the company decided to engage in the manufacture of refractories, he was placed in charge of development work in that field. In that year, he started the refractories works for the company at East Liverpool, Ohio, where he served as superintendent. As the refractories division continued to expand, he was responsible for the development and construction of the Augusta, Georgia, works and as a result was appointed general manager of the division in 1930. The Augusta works is today one of the most modern plants for the manufacture of refractory products. Mr. Kohler was educated in England, receiving his mechanical engineering degree from the City and Guilds College in London.

Mr. Phin joined the company in 1927 and has been in charge of accounting since that time. Before becoming comptroller for Babcock and Wilcox Company, he worked in public accounting in New York City and was associated for some time with Barrow, Wade, Guthrie and Company.

J. A. Ingwersen was elected to the position of vice president in charge of distribution for the American Rolling Mill Company, Middletown, Ohio. **C. H. Murray** was elected vice president in charge of personal and public relations; and **H. H. Tullis,** vice president and controller.

Mr. Ingwersen joined Armco in 1921, as employment interviewer, becoming chief interviewer in 1923. In 1925 he entered the sales department and served as a salesman until 1930, when he was made assistant manager of ingot iron sales section. He became manager of hot and cold rolled sheet sales in 1932, and in 1939, was appointed manager of mid-western sales. In 1940, he advanced to manager of sheet and strip sales, and in 1945 became general manager of sales.

Mr. Murray's connection with American Rolling Mill Company began in 1912. Immediately after completing business college, he started work in the labor department at the East works in Middletown. He served as a clerk in the company's storeroom and in 1914 became a timekeeper. In 1916 he began his career in personnel work, as an employment interviewer. He was advanced to the position of chief interviewer in 1921 and several years later was made supervisor of employment. He was appointed director of Armco's personal relations division in 1929.

Mr. Tullis' association with Armco began in 1928, in the controller's division. In 1929 he was in charge of personnel research and statistics and in 1930 became assistant statistician. Two years later he was appointed statistician and in 1931 transferred to personal relations division as staff supervisor of compensation and production standards. In 1936 he was appointed assistant controller, and was elected controller in 1944.

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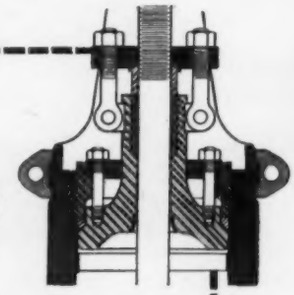

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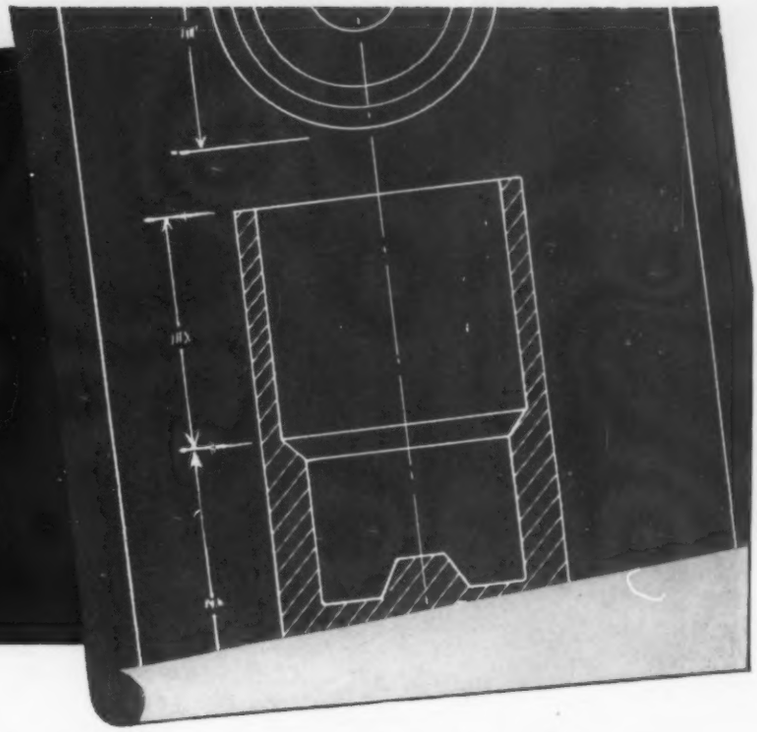

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The Allis-Chalmers 22-MV betatron is easily operated, requires little maintenance, and has low power consumption—about 30 KW during exposures. Standard industrial films are used; enlargements can be made directly.

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"A-C"s vast facilities plus 50 years of transformer experience and the inventive engineering of a staff of highly skilled technical men in betatron development from the first, have gone into the building of this valuable industrial tool. Technical information on request. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

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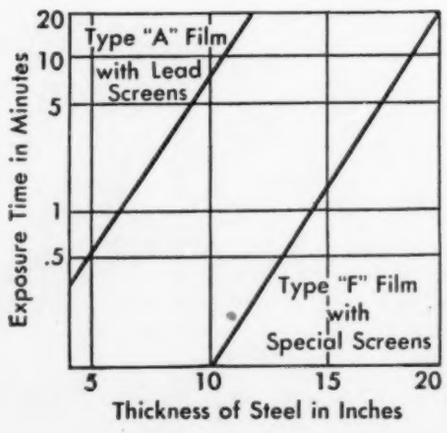
the betatron has a magnetic core, wound primary, and a donut-shaped evacuated chamber secondary in which electrons emitted from a filament travel in a circular path until nearly attaining the speed of light. They are then deflected from the circular orbit and strike a platinum target generating high frequency x-rays. Rays emerge in cone-shaped beam with focal point smaller than the head of a pin.



X-RAY EXPOSURE CHART

shows time required for x-raying various thicknesses of steel for the two most commonly used film types. This chart was plotted for a target-to-film distance of four feet.

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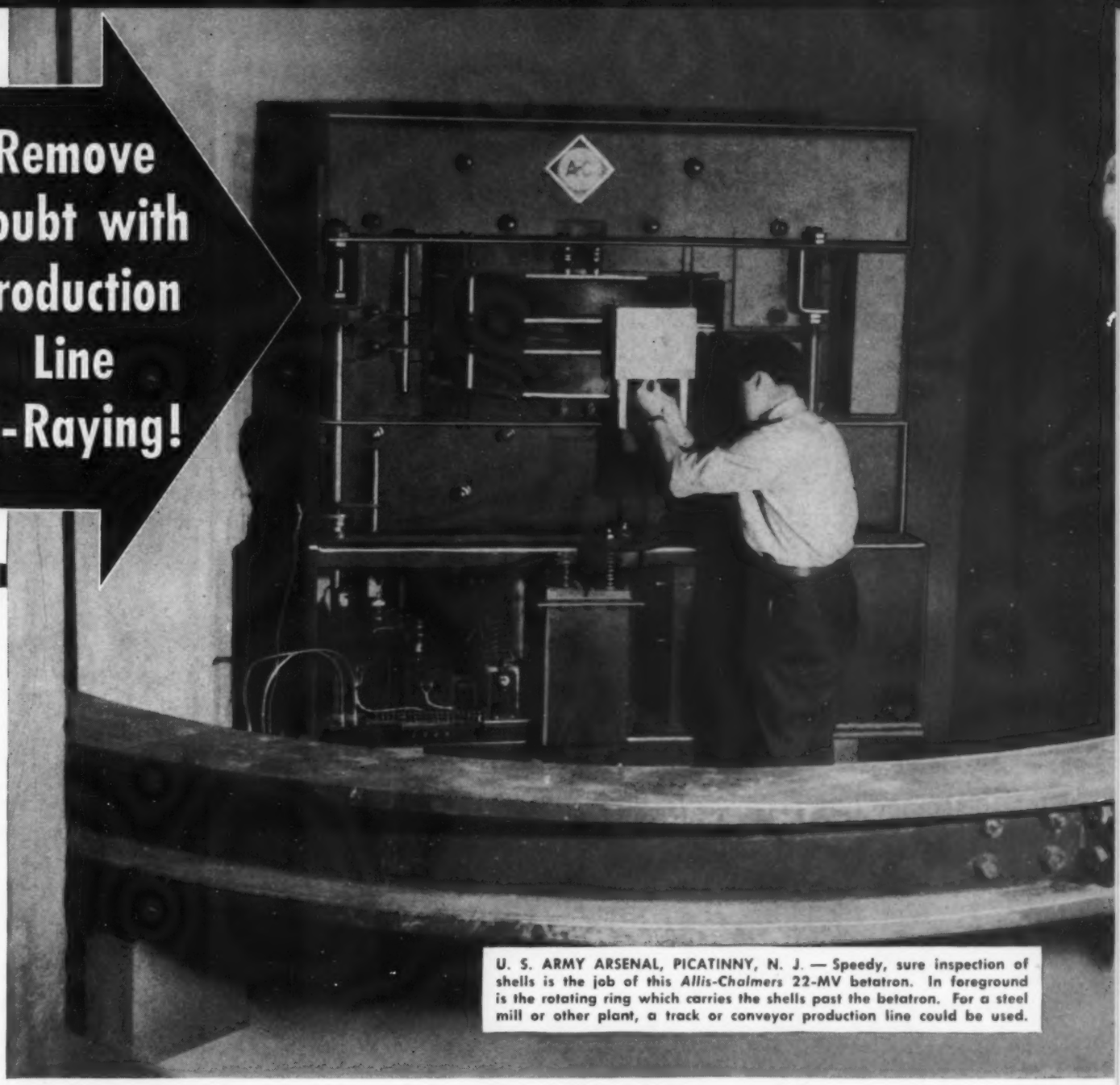
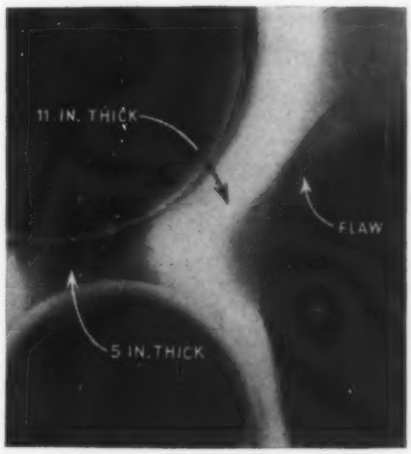


U. S. ARMY ARSENAL, PICATINNY, N. J. — Speedy, sure inspection of shells is the job of this *Allis-Chalmers* 22-MV betatron. In foreground is the rotating ring which carries the shells past the betatron. For a steel mill or other plant, a track or conveyor production line could be used.

SIMPLE PANEL CONTROL

reduces betatron operation to three steps. Also, the "A-C" 22-MV betatron automatically shuts off at the end of the predetermined exposure. Highly skilled technicians are not required . . . betatron x-raying requires a minimum of training of operating personnel.



BETATRON REVEALS FLAWS

saving money and time in machining. One radiograph enables several thicknesses of the same piece to be studied. This reproduction of an actual x-ray shows a defect in a steel forging that could ordinarily be detected only after long exposure with regular x-ray equipment or by expensive machining and testing.

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THESE NICKEL CAST IRON EXTRUSION PUNCHES..

Performed 12 times better than those of plain gray cast iron . . .

Machined extrusion punches of Nickel alloyed iron.* Wyman-Gordon use these punches in a 1500-ton press for making extrusions of Type 2512 Steel (5% Nickel) at a forging temperature of 2250° F. These punches measure about 10" long and 4" in diameter.

*Produced by
HUNT-SPILLER MFG. CORP.
South Boston, Mass.

Metal used for extrusion punches must be *tough* to resist breakage, *strong* to resist deformation, and *resistant* to heat effects involving checking, scoring and roughening.

Proper alloying with Nickel, along with chromium and molybdenum, results in cast irons that meet these rigid requirements.

The table below shows some of the data obtained from extensive tests made by The Worcester, Mass. Division of the Wyman-Gordon Company, a leading producer of aircraft forgings.

Extrusion punches provide just one more illustration of important advantages gained by using Nickel cast irons. In addition to their longer life of useful service Nickel irons can be conveniently cast and easily machined . . . thus effecting obvious economies. Our casting specialists will be glad to consult with you and suggest where Nickel Alloy Irons may be useful to you.

The low strength of unalloyed gray iron was responsible for this typical failure by fracture at root of stud recess after a short service life.

COMPOSITION AND SERVICE LIVES OF GRAY CAST IRON EXTRUSION PUNCHES

No.	TYPE	CHEMICAL COMPOSITION										Range of Lives	Average Life	B.H.N.	Type of Failure
		T.C.	G.C.	Si	Mn	P	S	Ni	Cr	Mo.	Cu				
1	Unalloyed	3.15	2.48	1.85	1.08	.22	.10	.00	.12	.02	.05	3-143	38	207-217	Broke
2	Mo.	3.10	2.50	1.88	1.12	.18	.06	.00	.15	.28	trace	13-399	122	223-228	Broke
3	Cu-Cr-Mo (Intermediate Phos.)	3.05	2.05	1.75	1.20	.24	.07	.00	.65	.45	1.50	2-56	28	217-241	Broke
4	Cu-Cr-Mo (Intermediate Phos.)	2.92	2.08	1.82	.96	.20	.09	.00	.46	.44	1.50	8-352	186	202-228	Broke
5	Ni-Cr-Mo (Low Phos.)	2.82	2.02	2.26	.86	.09	.08	1.83	.28	.71	trace	45-774*	311	228-240	Bent, Roughened or Broke
6	Ni-Cr-Mo (Low Phos.)	2.80	1.91	2.13	.64	.13	.07	2.28	.21	.78	trace	42-1370†	670	228-240	Bent, Roughened, Broke, or Stud Pulled Out

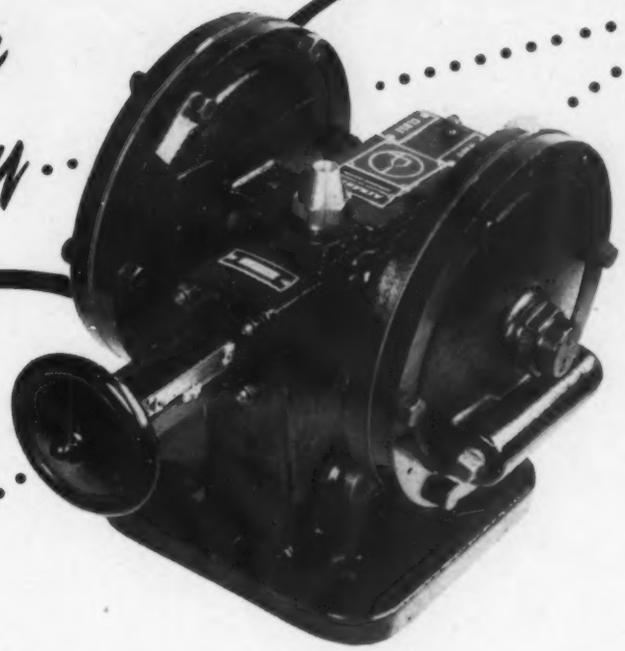
* 11 castings failed after making less than 240 forgings. 5 castings made more than 450 forgings. All others between 240 and 450 forgings each. † 7 castings failed after making less than 240 forgings. 3 castings made more than 1000 forgings. All others, 240 to 1000 forgings.

EMBLEM OF SERVICE
INCO Nickel
TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the selection, fabrication, treatment and performance of alloys containing Nickel. This information and data are yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

FOR CONTINUOUS AUTOMATIC PROPORTIONING WITH *Maximum Accuracy*..



THE ASKANIA RATIO REGULATOR

A simple, accurate way of mixing two or more liquids or gases to a predetermined ratio. Ratio can be changed easily without interruption of the process. • The Askania Ratio Regulator has only a few moving parts reducing maintenance to a minimum. • Low pressure systems use Fiberglas Diaphragms, measuring changes in conditions as small as .0025" W.C. • Turn down range of 10 to 1, with accuracy across full range. For control of fuel/air mixtures, for mixing propane-butane and natural gas, for processing change from batch to continuous mixing...for proportioning two or more gases, liquids or gases with liquids...use the Askania Ratio Regulator.

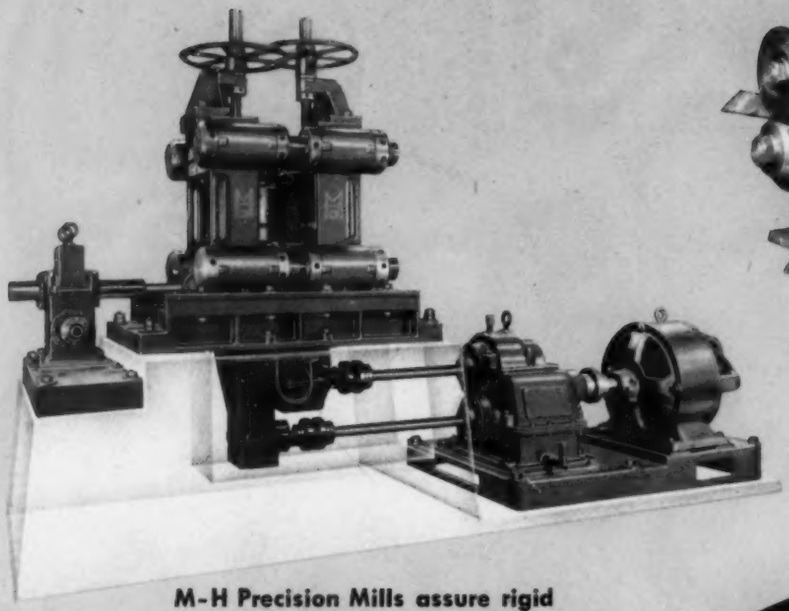
for detailed data get Technical Bulletin No. 101

OTHER ASKANIA EQUIPMENT AVAILABLE FOR THE ACCURATE CONTROL OF FLOW, PRESSURE, SPEED AND CONSISTENCY

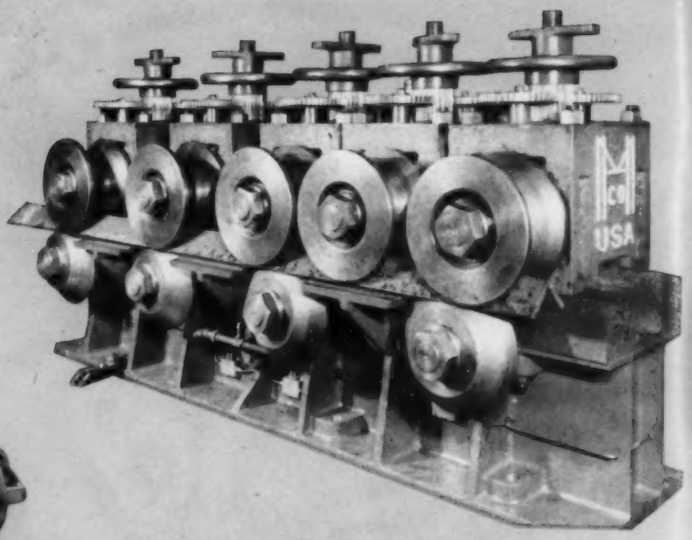
ASKANIA Controls

ASKANIA REGULATOR COMPANY

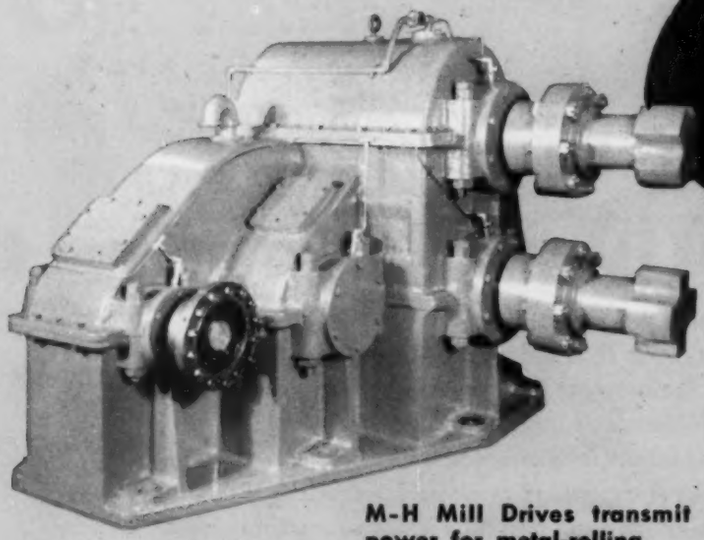
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION
240 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS
EXPORT OFFICE FOR LATIN AMERICA: 44 WHITEHALL ST., NEW YORK, N. Y.



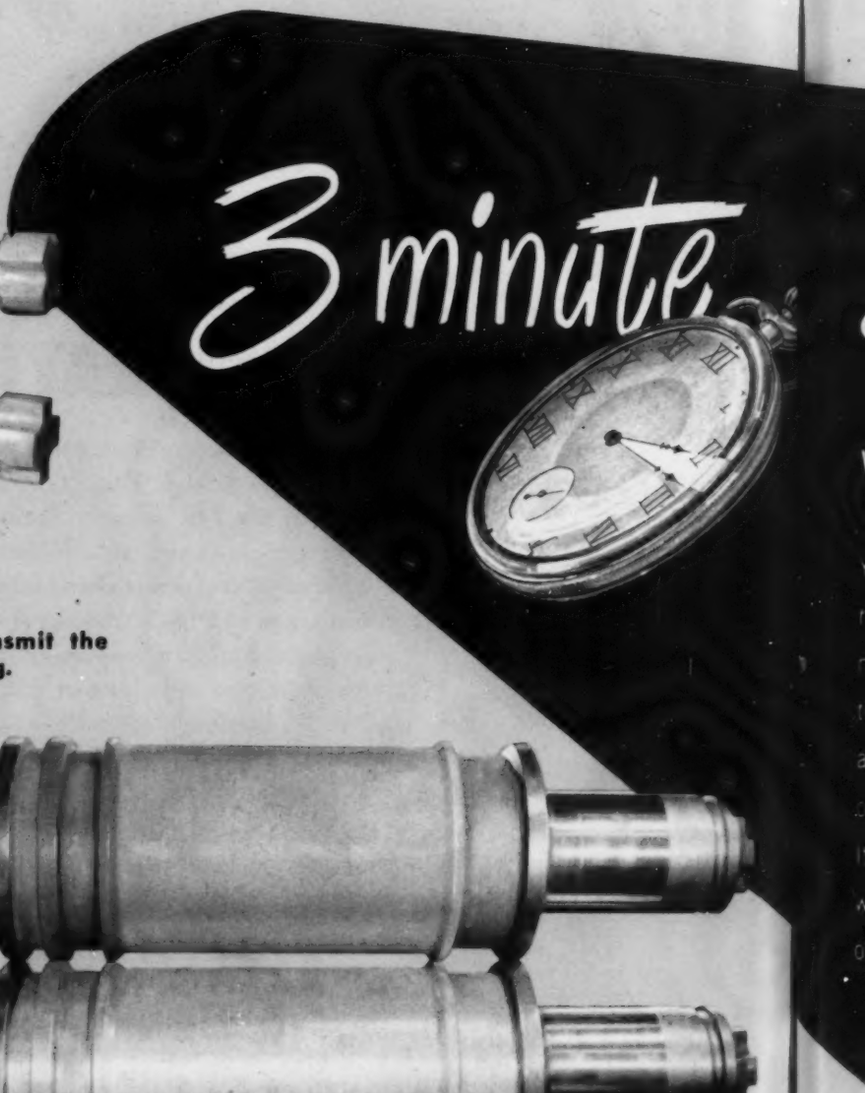
M-H Precision Mills assure rigid specification tolerances in rounds or shapes.

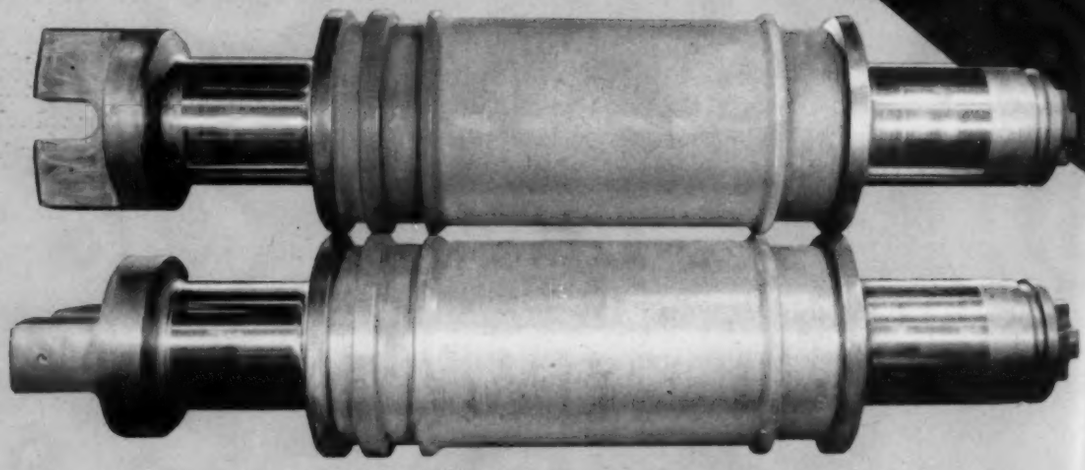


M-H Angle and Shape Straighteners, part of the M-H line of straightening equipment.



M-H Mill Drives transmit the power for metal-rolling.



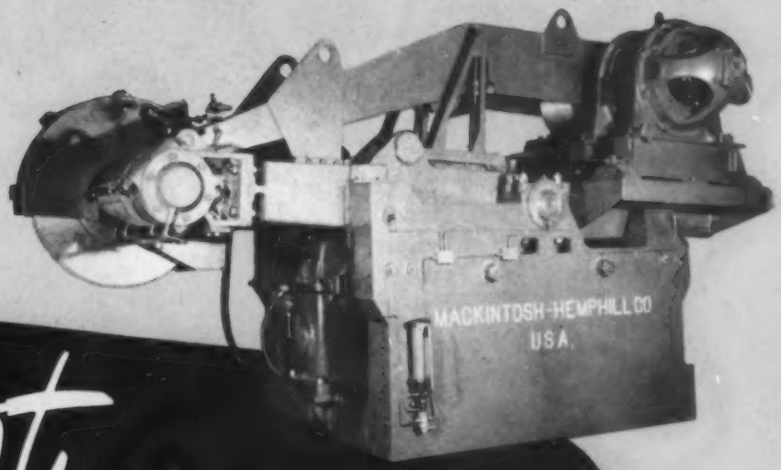


Rolls with the Red Wabblers will make short work of your production rolling operations.

M-H Strip Coilers for all types of metals, in all widths and coil weights.

M-H Heavy-Duty Lathes for the special productioneering requirements.

M-H Swing Type Hot Saws, and various types of shears, for high-speed cutting operations.

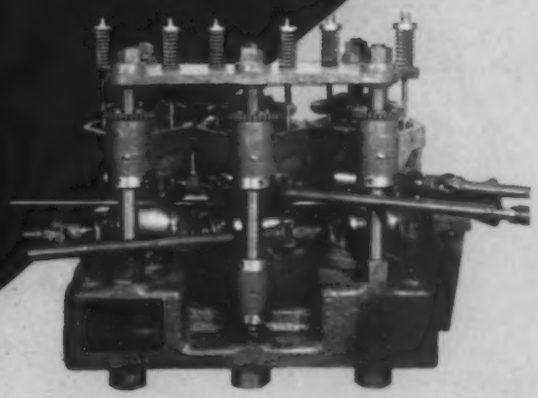


appointment

with Mackintosh-Hemphill

Your three minute reading time appointment will remind you of the widely diversified types of production machinery manufactured by Mackintosh-Hemphill, and point out that the Mackintosh-Hemphill engineering, metallurgical and manufacturing staffs are engaged constantly in the development of production equipment for the metals industry.

It will be worth your time to keep an eye on what's new at Mack-Hemp, to investigate these and other types of Mackintosh-Hemphill production machinery.



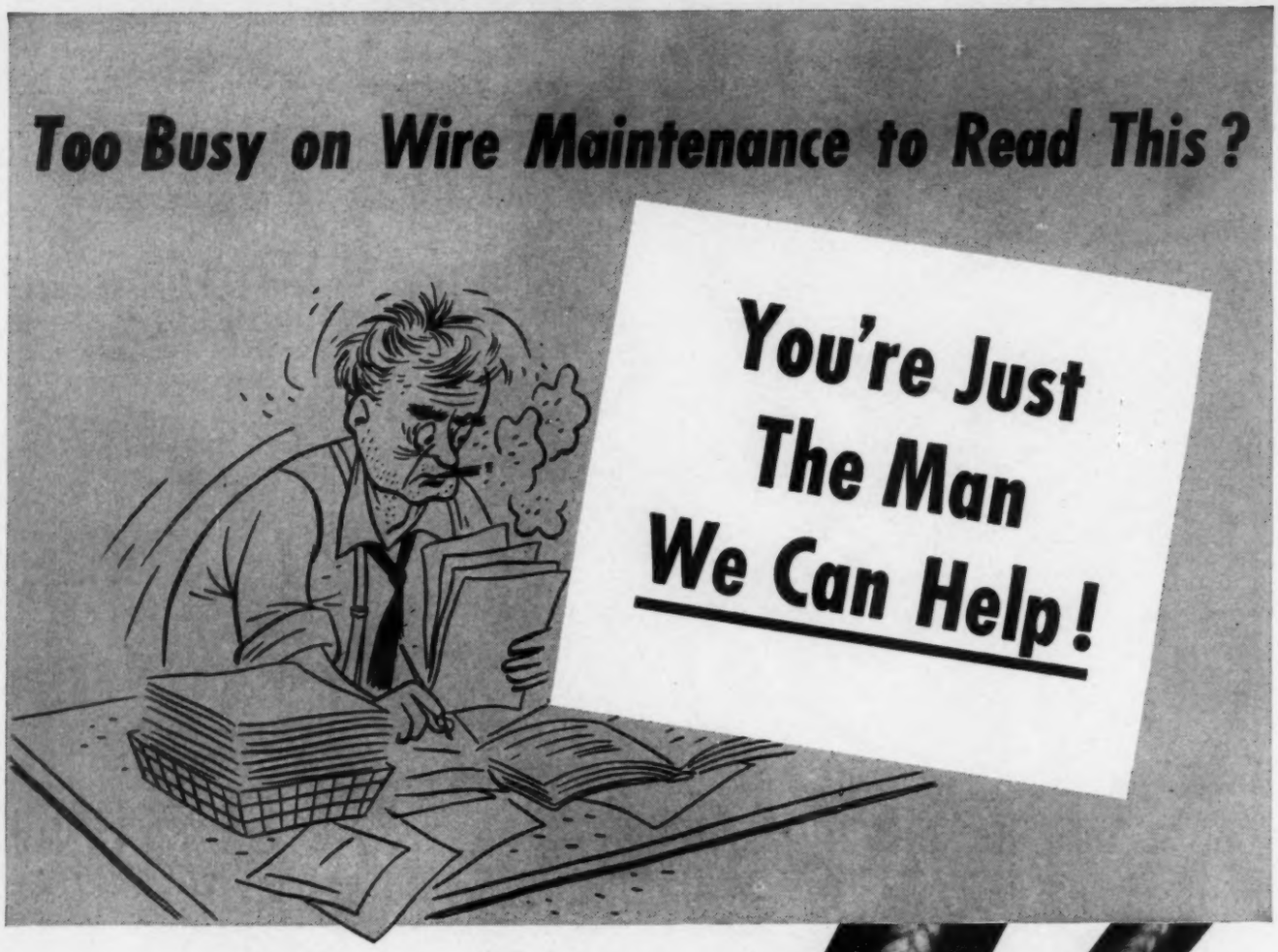
Mackintosh-Abramsen Straighteners remove all end-bends, leave no score-marks on finished products, require minimum setting-up time.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH—MIDLAND, PA.

Makers of the rolls with the Red Wabblers

Too Busy on Wire Maintenance to Read This?



If wire failures are a constant headache due to high ambient temperatures, overloads, deterioration caused by moisture, oil, grease, corrosive fumes and age . . . call in a Rockbestos engineer. He *can* and *will* solve your problem.

He'll give you the facts about Rockbestos A.V.C. wires and cables that guarantee long and trouble-free service under the toughest operating conditions because they are *permanently insulated* with heat and flame-resistant asbestos. This ageless insulator won't bake brittle, crack or flow in temperatures up to 230° F.

Hot spots shorten wire life and cause failures. Protect circuits around furnaces, pump rooms, boilers, kilns, soaking pits, steam tunnels and heat-exposed ducts with Rockbestos A.V.C. It pays its way by eliminating repeated re-wiring.

125 different standard Rockbestos wires and cables in 300 to 5000 volt ratings. Write for catalog and samples — or, if you prefer, the Rockbestos engineer nearest you will call with them.

ROCKBESTOS PRODUCTS CORPORATION
192 Nicoll St., New Haven 4, Conn.

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

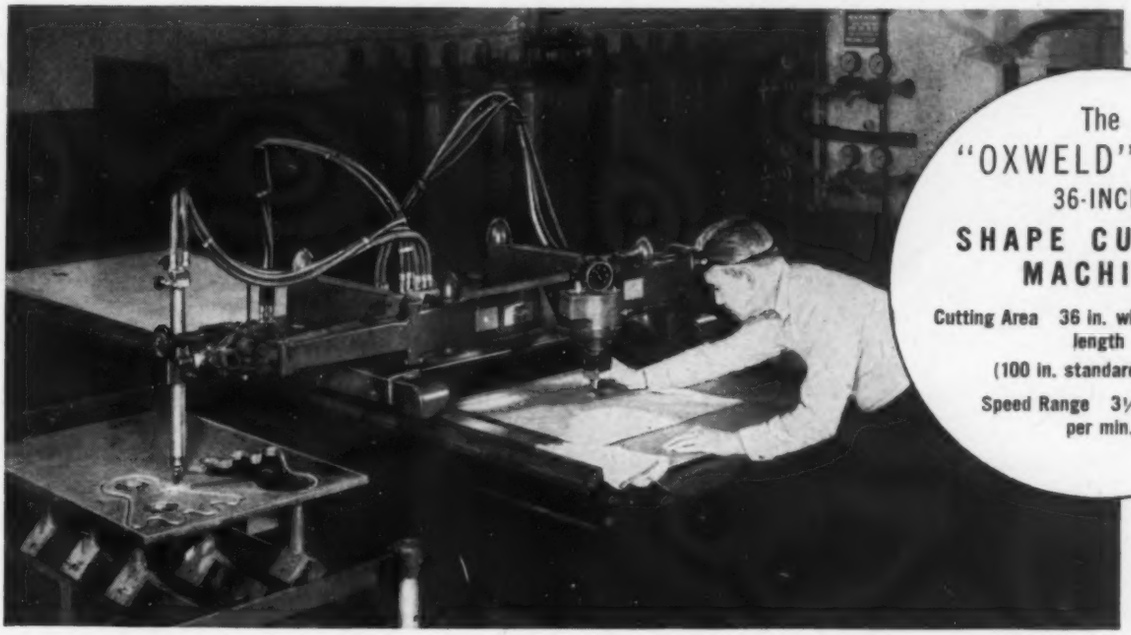
A few of the 125 different permanently insulated Rockbestos wires and cables designed to protect operations and reduce maintenance in control, lighting and power circuits. From left to right:

Type AVA 600 Volt Rockbestos A.V.C. Power Cable*
Type AVA 600 Volt Rockbestos A.V.C. Boiler Room Wire
Type AVB 600 Volt Rockbestos A.V.C. Switchboard Wire
*Other single and multi-conductor cables up to 5000 volt rating.

NEW YORK BUFFALO CLEVELAND PITTSBURGH DETROIT CHICAGO ST. LOUIS
LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

a new HIGH-PRODUCTION tool for SHAPING steel parts

. . . a new high-speed, high-capacity oxy-acetylene flame-cutting machine for mass production of steel shapes up to 36 inches wide.



The
"OXWELD" CM-15
36-INCH
SHAPE CUTTING MACHINE

Cutting Area 36 in. wide by unlimited length
(100 in. standard length)

Speed Range 3½ to 28 in. per min.

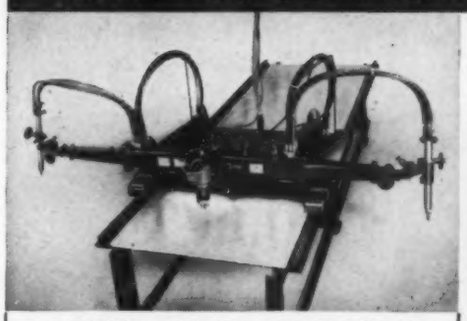
Line Tracing — Shapes to be cut can be traced from full-scale blue prints or drawings.

Strip Templet Tracing — Many parts of the same shape can be cut automatically by using a strip templet.

Magnetic Tracing — For repetitive cutting of complicated shapes with close tolerances, a magnetic tracing unit can be readily attached to the machine.

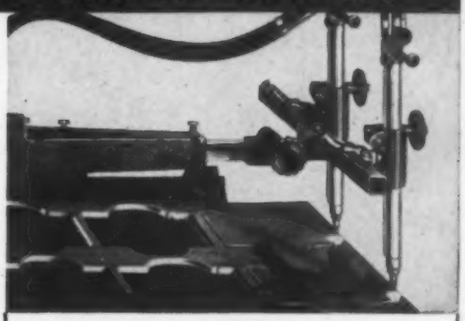
Call or write any Linde office for a descriptive folder. Ask for Form 6021.

BUILT FOR CUTTING PRODUCTION CORNERS



DOUBLE-ENDED OPERATION

Dual controls and blowpipe mountings provide for mounting blowpipes on either or both sides of the machine, and permit cutting on both sides simultaneously or cutting can be done on one side of the machine while plate is being set up on the other.



MULTIPLE OPERATION

Two free-moving pivoted arms mounted on the free-rolling carriage give blowpipe motion in any direction within the limits of the work area of the machine. An extension bar is available, for mounting more than one blowpipe on either side of the machine.

LINDE OXYGEN
PREST-O-LITE ACETYLENE
UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD, HELIARC, AND UNIONMELT APPARATUS
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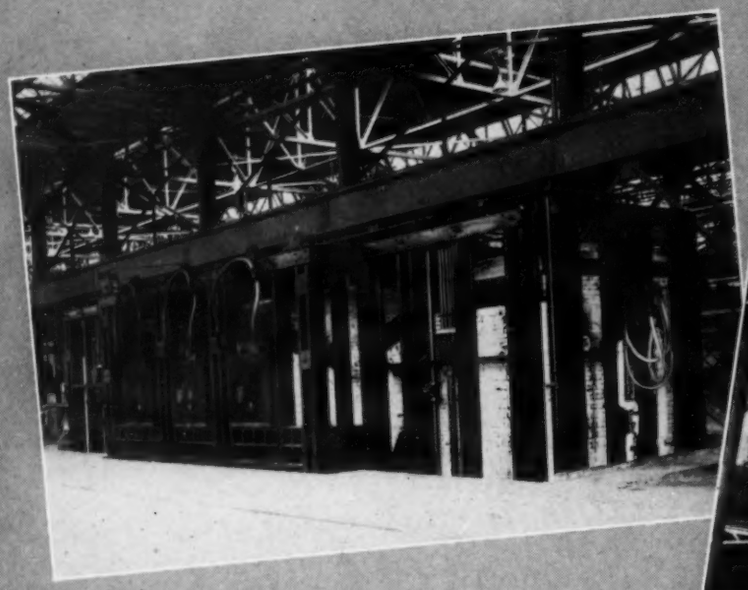

Water cooled Doors and Frames — Automatic Fuel Reversal control — Heavy Structural Framing

Water Cooled Reversing Valves and Dampers — Electric Door Hoists — Combustion Air Fan

Open Hearths, Stationary and Tilting, all capacities—Acid or Basic—Gas, Oil or Combination Firing Furnaces

Sound Design • Rugged Construction
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POWER TRANSMISSION MACHINERY by LINK-BELT Serves All Industry

Silverlink Roller Chains and Sprockets

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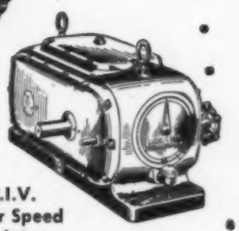
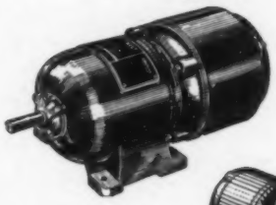
LINK-BELT BALL AND ROLLER BEARINGS

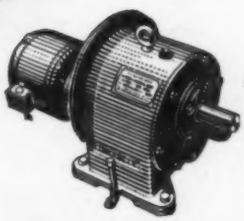
Steel, Malleable and Promal Chain Drives



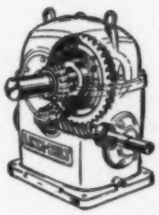
P.I.V. Gear Speed Variators



Electrofluid Drives

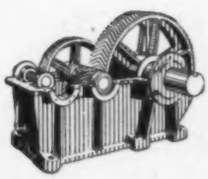


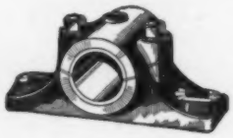
Motorized Helical Gear Speed Reducers



Worm Gear Speed Reducers

Herringbone Gear Speed Reducers





Babbitted Bearings — all types

ASSURE SERVICE SATISFACTION

Engineering principles and manufacturing methods of Link-Belt Ball and Roller Bearings are all pointed to the one objective: the assurance of "service satisfaction" to the user. They have many outstanding features which are making major contributions to that objective. Link-Belt bearings can be furnished in pillow blocks, cartridge, flanged, take-ups, hanger and duplex units or without mountings for machine applications, etc.

LINK-BELT COMPANY

THE LEADING MANUFACTURER OF CONVEYING AND MECHANICAL POWER TRANSMISSION MACHINERY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 10,819

THE SYMBOL OF QUALITY · LINK-BELT · LB

LINK-BELT Power Transmission Machinery

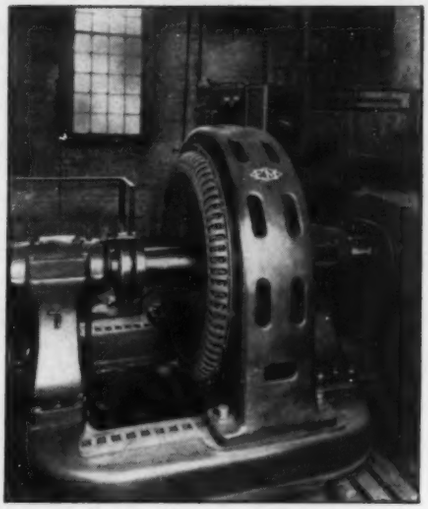
(*Continued from page 137*)

by the electric appliance and transformer divisions.

Carloadings at the East Pittsburgh, Pennsylvania, works in April increased 38 cars over March and substantial progress was made in supplying electric power generating equipment to utilities. Westinghouse has scheduled for delivery this year almost twice as many kilowatts of turbo-generator capacity as the company ever turned out before in a single year. Rapid progress is being made in supplying the demand for electrical equipment for new steel mills.

Despite the high rate of production, new business booked by Westinghouse in April greatly exceeded production with the result that unfilled orders also hit a new peacetime peak, amounting to $673,381,438 at the end of the month. Long deliveries are still the rule in many heavy apparatus lines and the production of Westinghouse appliances has not by any means caught up with the insistent demand.

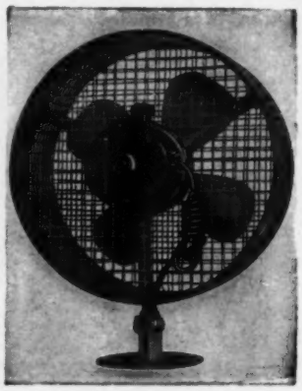
MOTOR RUNS 35 YEARS



This two-phase synchronous motor installed in 1913 at Henry Disston and Sons, Inc., manufacturers of saws, tools, files, knives, steel, is still in everyday hard service driving grinders in their plant at Philadelphia, Pennsylvania. One of the first heavy-duty synchronous motors ever built, it represented a pioneering effort of Electric Machinery Manufacturing Company to break the "inverted alternator" tradition which had limited synchronous motors to a few low-starting-torque jobs. Now synchronous motors perform heavy-starting duty throughout industry in a wide range of applications, and have become the recognized standard drive for many applications.

Rated 250 kw (equivalent to 315 hp) at 450 rpm, the motor shown drives three 2-stone band saw grinding machines on a lineshaft.

IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes

Keep Them COOL with TRUFLO FANS

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY
554 MAIN ST., HARMONY, PA.

BOOK REVIEW

▲ The July, 1947 issue of *Lubrication* magazine contains an article entitled, "Lubrication of Grinding Machinery." Remarkable progress has been made during recent years in the perfection of precision mechanisms. Surface finish is an important adjunct to the operation of such mechanisms. The grinding machine, therefore, became a most necessary device, for surface finish of machine parts is obtained by grinding.

Effective lubrication of the grinding machine spindle and the other parts contributes materially to coordination of speed and precision with the development of precision.

Copies of this magazine may be obtained from the advertising division of Texas Company, 135 East 42nd Street, New York 17, New York.

How to give a Bigger Bonus

...without budging your budget a bit!

SUPPOSE Bill S., one of your employees, is due for a $75 bonus this year. If you give the bonus in U. S. Savings Bonds, Bill will receive—not $75, nor a $75 Bond—but a *$100* Bond.

Yes, the bonus in Bonds looks like a lot more—and it *is* more. (Every $3 put into U. S. Savings Bonds pay $4 at maturity.) With the same size appropriation, you're actually giving a bigger bonus.

Consider, too, that Savings Bonds mean individual security for each Bond-holder—and collective security for all of us, because they help to control inflationary tendencies. You can easily see that you're doing yourself, your employees, and your country a favor by deciding to...

Give the BONUS in BONDS

...and keep up your Payroll Savings Plan!

IMPORTANT: If you have not already received your copy of "How You Can Help Give Free Enterprise a Boost," write on your letterhead to: Room 750, Washington Building, U. S. Savings Bonds Division, Washington 25, D. C. Limited supply. Please write today.

The Treasury Department acknowledges with appreciation the publication of this message by

IRON AND STEEL ENGINEER

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and The Advertising Council.

LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

WARE HI-LAG *Renewable* FUSES

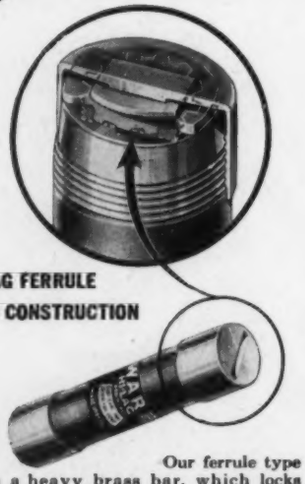
Double Fibre Bridge Assembly Increases Strength 10 Times

WARE HI-LAG Fuses have the strongest, most rigid knife blade assembly ever designed in fuses. The two heavy fibre bridges are supported by sturdy brass brackets which add greatly to the strength of the assembly. These bridge supporting brackets are attached to the copper knife blades and contact the entire end of links so that current flows through the brackets as well as the blades over a large area. Another reason for WARE HI-LAG Fuse's cool operation.

Perfect alignment is always maintained in this knife blade assembly with links centered in casing. The links are quickly and easily replaced or removed by loosening the nuts and slipping in or out.

Start using WARE HI-LAG Fuses today! Make them Standard Equipment for greatest economy and satisfaction. Investigate *now!*

Write for Brochure giving details of all the COOL FACTS, sizes and prices



HI-LAG FERRULE FUSE CONSTRUCTION

Our ferrule type fuse has a heavy brass bar, which locks into open end ferrule, bridging fuse case. This bridge locks link to prevent twisting and cap tightens on new center contact. No sagging washers or twisted links to cause overheating.

APPROVED BY UNDERWRITERS' LABORATORIES

WARE Brothers 4450 W. LAKE ST.·· CHICAGO 24, ILL.

now HAGAN *makes*

Ring Balance meters

Hagan Corporation has acquired all assets of Ring Balance Instrument Company, Chicago.

Manufacture of the full line of Ring Balance instruments will continue at the company's Chicago plant; the design staff has been retained; but these instruments will now be backed by the material and technological resources of the Hagan Corporation.

Sales and service will be handled by the present representatives of the Ring Balance Company, and by the district offices of Hagan Corporation. All activities will be directed from the Hagan offices in Pittsburgh.

* * *

With this acquisition, Hagan becomes the only manufacturer to offer an extensive line of flow meters based on the ring-balance principle.

The fundamental element in these instruments is a hollow ring-body mounted on knife edges so that it can rotate easily about its axis of symmetry. The lower part of this body is filled with a liquid which serves as a seal. A partition across the upper part divides the ring into two distinct compartments, one of which is connected to the high pressure tap of an orifice, flow nozzle, venturi, or similar primary element. The other compartment is connected to the low pressure side of the element.

These connections are made by means of special flexible tubes. These tubes are an exclusive Ring Balance patented feature.

The torque created by the *differential pressure acting on the partition* causes the ring-body to rotate. A torque opposing this rotation is brought into play by an external counterweight rigidly attached to the ring-body or other suitable resistance systems. In either case the assembly is a symmetrical *ring balance*, and rotates only until the torque due to differential pressure is balanced by the torque exerted by the resistance system.

By means of a suitable linkage and cam, the angular movement of the ring balance is converted into readings of the rate of flow on an appropriate scale and in any desired units. In the ring balance meter the calibration is not dependent on the amount of sealing liquid.

All instruments in the extensive Hagan Ring Balance line incorporate this fundamental principle and thus have certain inherent advantages.

1. They have a very high ratio of power to friction.
2. Meter capacities can be changed simply without taking meters out of service or dismantling them.
3. They can be calibrated without being disconnected or removed from service.
4. There is no stuffing box.

We will be glad to give you full information concerning Hagan Ring Balance instruments which have applications in your plant. Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

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RING BALANCE FLOW AND PRESSURE INSTRUMENTS
BOILER COMBUSTION CONTROL SYSTEMS

THE ENGINEERING MART

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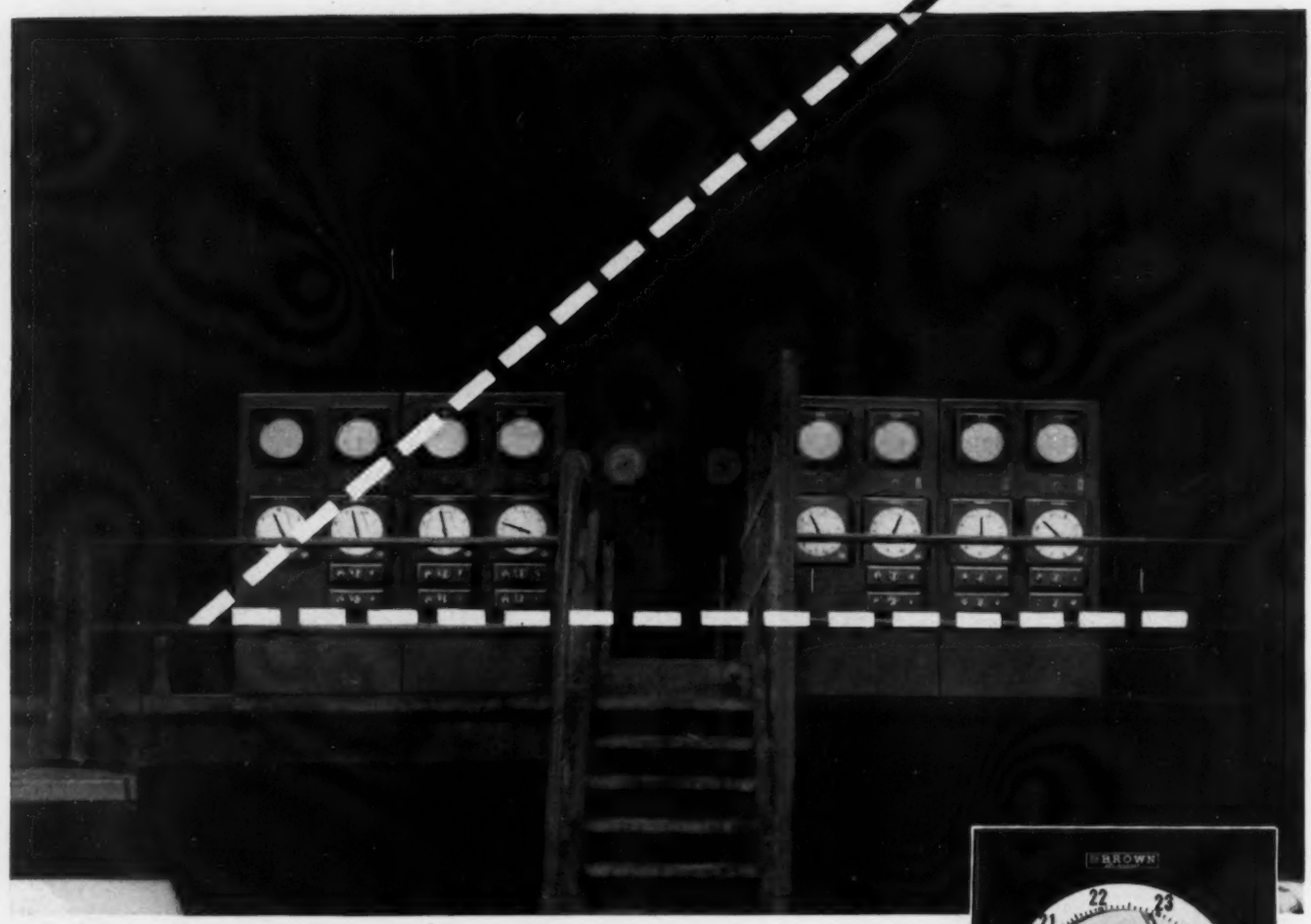
...with Brown ElectroniK Air-o-Line Controllers

Consistent temperatures — greater tonnage per furnace — greatly reduced effect of mill delays — less cinder — are the results of using Brown ElectroniK Air-o-Line Controllers on slab, billet and merchant mill furnaces.



The triple fired slab heater illustrated includes automatic control of each zone — plus automatic limit on preheat air temperatures and manual regulation of holding burners. Quick shifting from one fuel to another is accomplished through automatic control panels.

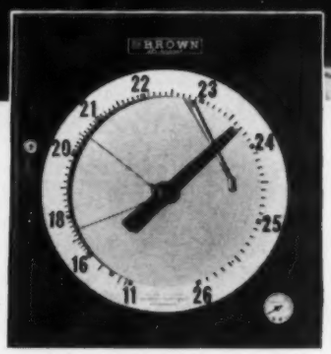
ElectroniK "Continuous Balance" Potentiometers — provide the basis for better control and, since they are unaffected by vibration, allow installation immediately over the roll table where the operator can see both the instruments and the slabs.

Air-o-Line control — simplifies installation and maintenance. Air-o-Motor valves better withstand the high temperatures encountered.

Radiamatic detection — gives greater accuracy, freedom from maintenance; and does not require water cooling.

This unbeatable combination has established proven performance by six years of steel mill service.

Write for further information on Brown Heating Furnace Control Systems or for Catalog 15-4R describing the ElectroniK Air-o-Line Potentiometer.



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"SUPEREX sure stands up!

...You can take my word for it. I've used it behind refractory linings for over 20 years!"

SO SAY steel men everywhere. Oil men, too—in fact, practically everyone who handles high temperature equipment. You can't beat Superex as a block insulation for temperatures up to 1900 F. That's why it's behind more refractory linings than any other block type insulation.

These seven reasons give the Superex story in a nutshell:

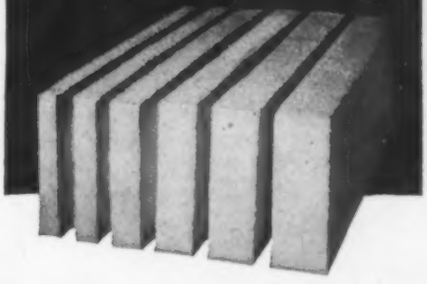
1. **Low Thermal Conductivity**—Superex is made from specially selected calcined diatomaceous silica, bonded with asbestos fibre—presenting a formidable barrier to the passage of heat.
2. **High Heat Resistance**—J-M Superex Blocks safely withstand temperatures up to 1900 F. without deterioration.
3. **Lightweight**—Approximately 24 lbs. per cu. ft.
4. **High Physical Strength**—Withstands vibration and other physical abuse encountered in normal service. Approximately five tons pressure per square foot are required to compress Superex ⅛ inch.
5. **Permanent Efficiency**—Superex maintains high thermal efficiency indefinitely—will not disintegrate in service for which recommended.
6. **Quick Application**—The convenient sizes and lightweight of Superex assure fast, economical installations.
7. **Easy Cutting and Fitting**—Superex is easily cut with an ordinary knife or saw for fitting around openings or irregular surfaces.

Special shapes and curved blocks—in addition to the 6 standard thicknesses illustrated—can be supplied. Write Johns-Manville, Box 290, New York 16, N.Y.

JOHNS-MANVILLE JM PRODUCTS

Superex blocks are finished in various standard sizes and thicknesses.

1½"–2"–2½"–3"–3½"–4"



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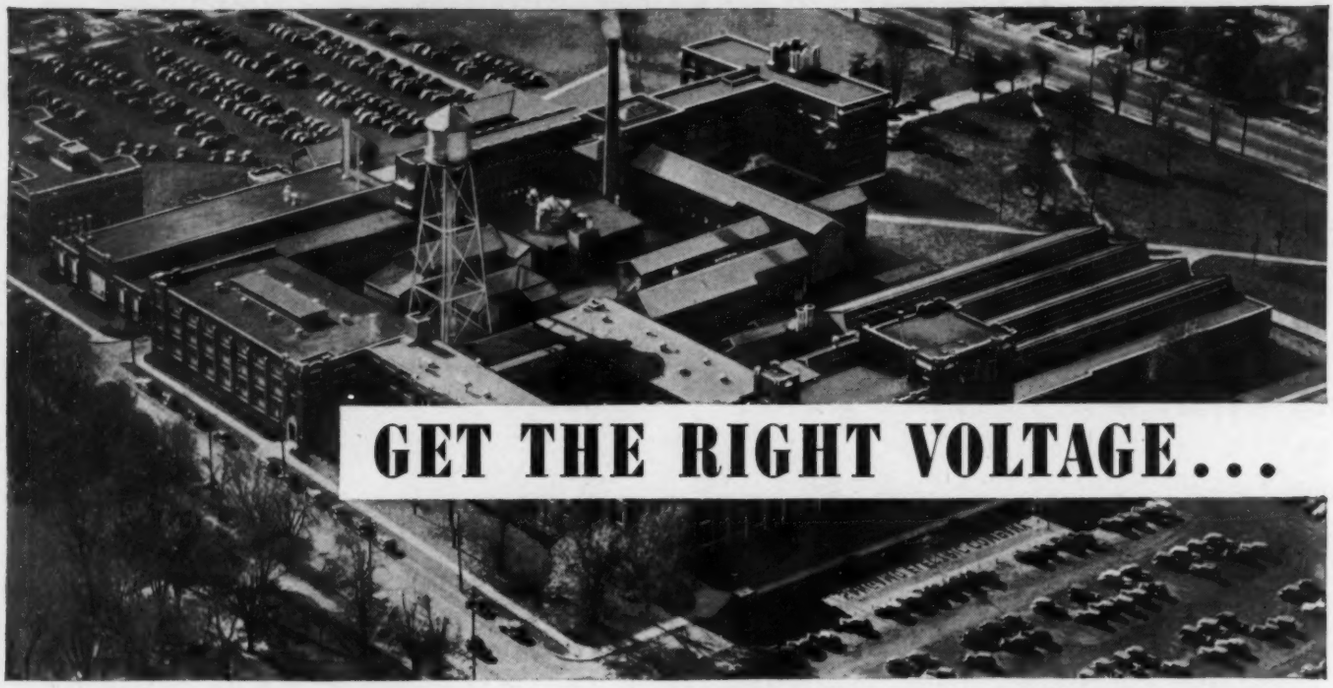

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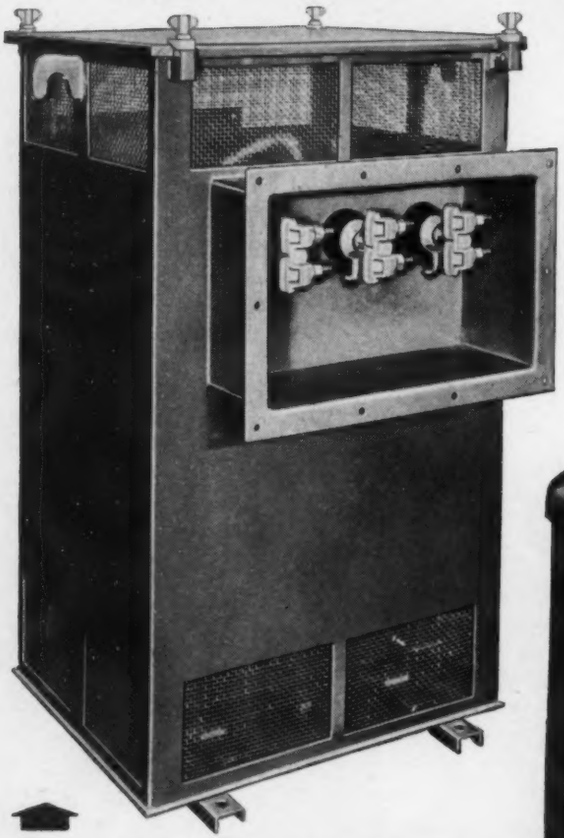

A 100 kva two-winding air-cooled transformer, showing typical construction used in the larger units, which are designed for indoor service only.

RIGHT WHERE YOU NEED IT with Wagner

Air-Cooled Dry-Type Transformers

Do you have electrically driven equipment in your factory, office, store or home that requires higher or lower voltages than your lighting or power circuits provide? Chances are you do. And chances are better that the safest and most economical way to get the right voltage right where you need it is to install Wagner air-cooled dry-type transformers.

Wagner air-cooled transformers can usually be installed exactly where needed. They do not require special vaults, even in locations where fire hazards are present; this means lower installation costs, and lower insurance rates.

Wagner's complete line of distribution and power transformers also includes air-cooled unit substation transformers in ratings from 100 to 2000 kva. Write for Bulletins TU-180 and TU-181. Wagner Electric Corporation, 6483 Plymouth Ave., St. Louis 14, Missouri, U. S. A.

Typical construction of two-winding air-cooled transformers through 10 kva, and air-cooled auto-transformers through 25 kva. These sizes can be installed indoors or outdoors.

Consult Wagner Engineers on All Transformer Problems

Wagner Electric Corporation EST. WE 1891

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ELECTRICAL AND AUTOMOTIVE PRODUCTS

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INDEX TO ADVERTISERS

A

Aetna-Standard Engineering Company 1
Air Reduction Sales Company 133
Alliance Machine Company 104
Allis-Chalmers Manufacturing Company 150, 151
American Brakeblok Division, American Brake Shoe Company 25
American Chemical Paint Company 131
American Hammered Piston Ring Division of Koppers Company 134, 135
Askania Regulator Company 153
Automatic Transportation Company 10

B

Babcock & Wilcox Company, The 129
Bailey Meter Company 105
Baker Industrial Truck Division of The Baker-Raulang Company 24
Bantam Bearings Division of The Torrington Company 128
Bedford Foundry and Machine Company 147
Birdsboro Steel Foundry and Machine Company 108
Blaw-Knox Division, Blaw-Knox Company 122
Bloom Engineering Company 130
Bonnot Company 19
Bowser, Inc. 140
Brassert & Company, Ltd., H. A. 32
Brown Instrument Company 168
Buffalo Forge Company 23
Bussmann Manufacturing Company 102, 103

C

Clark Controller Company 110, 111
Cleveland Crane and Engineering Company 28
Cleveland Worm and Gear Company, The ..... Cover 3
Continental Foundry and Machine Company 115, 116
Crane Company 148
Crouse-Hinds Company 121
M. E. Cunningham Company 147
Cutler-Hammer, Inc. ..... Cover 2

D

Deltabeston Division, General Electric Company 127
Dowell, Inc. 6
Dravo Corporation 109

E

Electric Controller and Manufacturing Company 8
Engineering and Construction Division of Koppers Company 134, 135

F

Falcon Bronze Company 142
Flinn and Dreffein Company 32

G

Gamlen Chemical Company 144
Gas and Coke Division of Koppers Company 134, 135
General Electric Company ..... Cover 4

H

Hagan Corporation 165
Hallden Machine Company 32
Hays Corporation, The 123
Hydropress, Inc. 3

I

Ideal Industries, Inc. 144
International Graphite and Electrode Corporation 149
International Nickel Company 152
I-T-E Circuit Breaker Company 20

J

Johns-Manville Corporation 136, 169
Jones Foundry and Machine Company, W. A. 132

K

Kling Brothers Engineering Works 146
Koppers Company 134, 135
Koppers Coal Company, The 134, 135
Koppers-Rheolaveur Company 134, 135

L

Leeds and Northrup Company 12
Lewis Foundry and Machine Division, Blaw-Knox Company 120
Lincoln Engineering Company 14
Linde Air Products Company 157
Link-Belt Company 161
Lintern Corporation 141
Loftus Engineering Corporation 160
Lumnite Division, Universal Atlas Cement Company 21

M

Mackintosh-Hemphill Company 154, 155
Maryland Drydock Company, The 134, 135
Mathews Conveyer Company 125
McKay Machine Company 21, 32
Mesta Machine Company 101
Morgan Construction Company 5
Morgan Engineering Company 112
Morganite, Inc. 145

N

National Bearing Division, American Brake Shoe Company 18
National Roll & Foundry Company 2
New York and New Jersey Lubricant Company 147

O

Okonite Company, The 11

P

Peerless Pump Division, Food Machinery Corporation 137
Pennsylvania Transformer Company 27
Philco Corporation, Storage Battery Division 31
Pittsburgh Lectromelt Furnace Corporation 34
Pittsburgh Rolls Division, Blaw-Knox Company 15
Poole Foundry and Machine Company 4
Post-Glover Electric Company 13
Pyle-National Company 124

R

Ready-Power Company, The 126
Reliance Electric and Engineering Company 7
Rockbestos Products Corporation 156
R-S Products Corporation 119

S

Salem Engineering Company 16
Shops Division, Koppers Company 134, 135
Smeeth-Harwood Company 142
Steel Processing Company 118

T

Tar and Chemical Division of Koppers Company 134, 135
Texas Company, The 9
Tide Water Associated Oil Company 30
Timken Roller Bearing Company 22
Torrington Manufacturing Company, The 172
Truflo Fan Company 162
Trumbull Electric Manufacturing Company, The 143

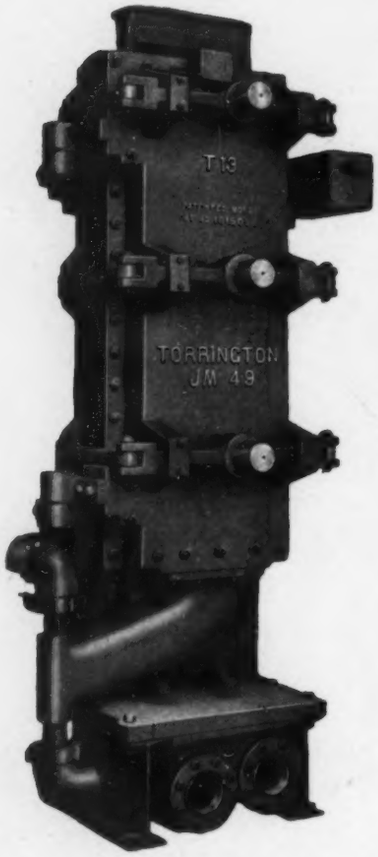
U

Union Carbide and Carbon Corporation 157
United Engineering and Foundry Company 17

W

Wagner Electric Corporation 170
Wapakoneta Machine Company 117
Ware Brothers 164
Wean Engineering Company, Inc., The 32
Wean Engineering Company of Canada, Ltd. 32
Wean Equipment Corporation 32
Western Gas Division of Koppers Company 134, 135
White Tar Company of New Jersey, Inc., The 134, 135
Williams Gauge Company, The 139
Wing Manufacturing Company, L. J. 119
Wilson Engineering Company, Inc., Lee 26
Wood Preserving Corporation, The 134, 135

Another TORRINGTON *Special*



(Patents Pending)

WATER-COOLED MOLDS
FOR COPPER-BEARING ALLOYS
SPEED PRODUCTION . . . CUT COSTS

The Torrington Manufacturing Company's water-cooled molds cool in a few minutes as against the 1 to 4 hours required by air-cooled molds. Also, the life of the molds is enormously extended. Air-cooled molds usually last for only a few hundred slabs, rarely as many as 3,000. Torrington water-cooled molds average between 14,000 and 25,000 slabs per mold—up to 20,000,000 pounds—before replacement of either copper faceplate becomes necessary. And replacement plates are relatively inexpensive, due to salvage of the worn-out plate. Mold cost per pound of metal is infinitesimal, since replacement of the faceplates is usually the only maintenance expense.

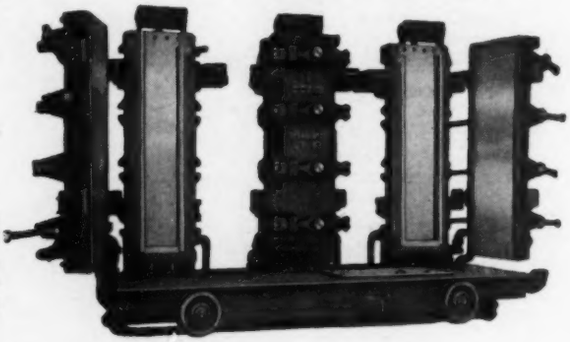
CASE HISTORY

One of the largest producers of brass used 32 Torrington water-cooled molds through 3½ war years. 21 of the original 64 plates are still usable. The number of 1,400-pound slabs cast against each plate ranged from 14,511 to 24,362. A clamp-type plate having no bolt holes on the sides was used for a total of 28,993 heats.

SPECIFICATIONS

Water-cooled molds can be built to any size or specification, and will cast any of the copper-bearing alloys. They are scientifically designed so that the water flow cools all parts of the plate evenly. Clamp type plates, with a minimum of bolts, reduce breakage by permitting expansion and contraction.

Torrington builds any type (water- or air-cooled) slab or billet molds for copper-bearing alloys.



Two or three molds on one truck, when casting smaller bars, enables full discharge of furnace. The truck makes possible quick, easy movement between furnaces, for full utilization of mold capacity.

For over 60 years, Torrington Manufacturing has been designing and building special machinery for processing sheet, strip, flat wire, rods and tubes, as well as air-cooled or water-cooled molds for casting copper-bearing alloys. Fine modern facilities include a highly trained design and engineering staff, pattern shop, forge shop, hardening room, welding shop, completely equipped machine shop, and large assembly floor covered by cranes. Experienced, skillful men work under ideal conditions. Our standard designs can be modified to meet special requirements and we work closely with customers' engineers in adapting machines or designing and building new machines. This collaboration assures special attention to maintenance and production problems. Privacy is guaranteed when we build from customers' drawings or design and build under their supervision. Materials and workmanship are also guaranteed.

Call or write Torrington Manufacturing with complete details of your requirements. We'll not only build a machine to suit your specifications, but will also help set it up and start it in production in your plant.

The **TORRINGTON**
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT

As the white outline indicates, a standard unit of much greater frame size would be required to do the work of Speedaire.

SPEEDAIRE delivers, rain or shine

OPERATING outdoors in all kinds of weather, protected only by a piece of sheet iron, this Speedaire drives a reciprocating feeder that empties slate from the storage bin above it into dump cars.

Three compelling reasons led the Coal Company to install Speedaire instead of a conventional worm gear reducer: Speedaire weighed 30% less—it required 26% less headroom—it saved $50.50.

Speedaire is Cleveland's new fan-cooled worm-gear speed reducer. Because it is fan-cooled, Speedaire will do more work—will deliver up to *double the horsepower* of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore—giving you the advantages of a compact right-angle drive. Speedaire gives the same long, trouble-free service characteristic of all Clevelands.

For full description, send for Catalog 300. The Cleveland Worm & Gear Co., 3278 E. 80th St., Cleveland 4, O.

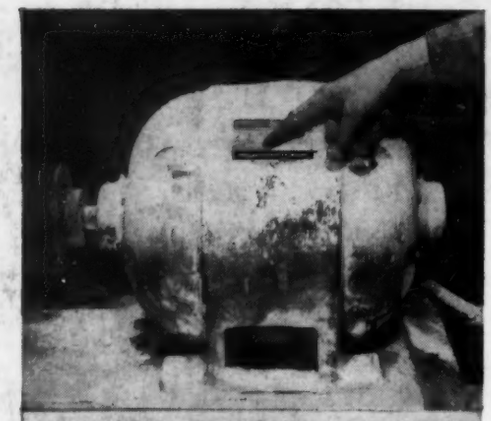
Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

ON 1,220,000 MOTORS

TRI CLAD

THE SYMBOL OF EXTRA PROTECTION



Keeps Its Bearings in "Dust Bowl"

Ordinarily, we wouldn't recommend that you use an open motor on a job like this. This Tri-Clad motor drives a boiler-feed pump in the National Gypsum Company plant at Clarence Center, N. Y. The air surrounding the motor is constantly filled with gypsum dust which must be kept out of the bearings. And it *has* been kept out of the bearings of this Tri-Clad motor, thanks to its specially designed bearing housing and seals. We believe that the Tri-Clad motor you see here proves that even where dust, moisture, or some other hazard is extremely severe for open-motor applications, the extra protection afforded by Tri-Clad motor construction results in longer motor life and lower upkeep.

The toughest motor yet!

The Tri-Clad totally enclosed, fan-cooled motor is designed for use in adverse atmospheres — in iron dust, out of doors, in hazardous areas, and chemical atmospheres. It gives you these important construction features:

- A cast-iron, double-wall frame which completely encloses and protects the windings and punchings.
- A nonshrinking compound around motor leads which protects motor interior from dust and moisture.
- A rotating labyrinth seal which further protects the motor interior from damage by foreign matter.

Announcement of the Tri-Clad motor, back in 1940, ushered in a new concept of general-purpose motor design. Substantially increased horsepower-per-frame-size was one feature. Smarter appearance was another. But what really sold more than a million Tri-Clad motors is the *extra protection* we built into them.

Today, with the "family" including dripproof motors, vertical motors, gear-motors, capacitor-motors, and totally enclosed motors, Tri-Clad motor is, more than ever, the motor that means basic protection, dependable performance, and minimum upkeep. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

EXTRA PROTECTION... AGAINST PHYSICAL DAMAGE!

Rigid cast-iron frame and end shields protect vital parts from external abuse and prevent resonance. Because they're not at the mercy of a coat of paint, they strongly resist chemical attack and dampness. Cast iron also gives you tight, *metal-to-metal* fits between end shields and frame.

EXTRA PROTECTION... AGAINST ELECTRICAL BREAKDOWN

Windings of Formex* wire together with improved insulating materials, reduce the chances of electrical failure. Heat is dissipated quickly — motor stays young for years and years.

EXTRA PROTECTION... AGAINST OPERATING WEAR AND TEAR!

Bearing design affords longer life, greater capacity, improved lubrication features. Bearing seals retain lubricant, keep out dirt. One-piece, cast-aluminum rotor is practically indestructible.

*Trade-mark reg. U. S. Pat. Off.

TRI CLAD
REG. U.S. PAT. OFF.
MOTORS

GENERAL ELECTRIC

700—256C